# THE GEOGRAPHY OF STOMACH CANCER IN THE UNITED STATES

By

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THE GEOGRAPHY OF STOMACH CANCER

IN THE UNITED STATES

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## PREFACE

This thesis is concerned with the geography of stomach cancer in the United States. The primary objective is to spatially define the existing variations of stomach cancer through maps and to statistically find relationships with selected demographic, occupational, and socio-economic variables.

When it came time to write the acknowledgments there were many individuals who were responsible for the completion of my thesis and more important my master's degree in geography. I would like to thank the following individuals.

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## GLOSSARY

Benign: Not cancer. An abnormal swelling or growth that is usually harmless.

Cancer (Malignant Neoplasms): A general term for more than 100 diseases all of which have an uncontrolled growth of cells. The resulting mass, or tumor, can invade and destroy surrounding normal tissues. Cancer cells from the tumor can spread through the blood or lymph system to start new cancer in other parts of the body.

Carcinogens: Any substance that has the potential of developing cancer. Carcinogens can occur in food products and industrial air pollution.

Environmental: All of the factors surrounding an individual that affect his or her life and sometimes the life of the community. Includes air, water, food, smoking, and radiation.

Epidemiology: The branch of medicine dealing with the location of diseases.

Etiology: The study of finding the causes of diseases.

Metastasis: The process by which cancer cells break away and spread to other places in the body through the lymph and blood system and new cancers in other parts of the body.

Mortality: The number of deaths due to the disease occurring during a given time in a specific population. Usually given in deaths per 1,000 or 100,000 population.

Nutrients: The parts of food that nourish the body. Includes vitamins, minerals, proteins, fats, carbohydrates, and water.

Tumor: A swelling or enlargement, either benign or malignant, which performs no useful body function.

# CHAPTER I

## BACKGROUND

This thesis falls within the field of medical geography. Its purpose is to illustrate the spatial patterns of stomach cancer mortality through space and time. The years under study will be from 1940 to 1973. The selection of this time period is attributed to the collection of pertinent data from census information for each state. To better understand the geographic variability of cancer mortality, maps are used to indicate the occurrences of cancer. This study is intended to indicate states or a state that has changed in mortality over time. Such maps may be of use for pinpointing states with consistently high or low rates over time, or clusters of states.

Today there is a pronounced awareness of the importance of understanding the geographic aspects of cancer that affects man's well being. In today's ever changing society it seems as though the physical environment is playing a vital role in causing some form of cancer among individuals. The geography of the land such as the location of chemical industries, pollution, and also the cultural habits of ethnic groups are major factors in explaining the spatial pattern of cancer. The outcome is undoubtedly a development of some form of cancer in the later years of one's life. Finding out where cancer is occurring, especially the high mortality areas, hopefully will bring about an awareness on

behalf of the general population, This spatial awareness could bring about cancer programs which can help control it or establish centers to help alleviate this disease. Cancer is somewhat controlled by numerous drugs, and some understanding has been developed on what causes certain cancers. Yet, so much is still not known on the spatial patterns of cancer. The role of the medical geographer is to locate the high cancer areas and try to better understand the reasons why some cancers are located in certain sections of the country and not in others. By knowing this element another positive step forward can be added to cancer research and possibly lead to better understanding of the etiology of cancer.

The selection of cancer as a research topic came about from noticing changing mortality trends in the United States through time and a defined spatial pattern has developed for various types of cancer. Even though there are a multitude of cancer categories this thesis is only concerned with stomach cancer. The underlying purpose of this research is to bring about the understanding of stomach cancer from a researcher's point of view and also from a humanitarian point of view.

## Cancer in General

Cancer is a chronic and serious illness with a long latent period required for its development and is not subject to epidemic fluctuations. Cancer has always ranked high as a cause of death in more advanced societies and even the most sequestered people are prone to getting cancer.[1] So in a way one cannot prevent cancer even though one can take precautionary measures. Stomach cancer, in common with all cancer, is a disease of the body cells. These cells makeup the various parts of

the body: the skin, heart, lungs, bones, stomach, etc. Stomach cells differ from skin or bone cells in shape and function, all cells do share a common characteristic in their ability to reproduce themselves.[2]

The word cancer is derived from the Greek word meaning "crab," karkinos which means new growth. As the cancer cell moves within the body the cancer cell reaches outward like a crab would. The cancer cell will build up into malignant tumors which will invade and destroy healthy tissues. The vital organs are affected and if untreated with medical care, death will occur. Malignant tumors all share the following characteristics:[3]

1. Higher rate of cell growth than normal tissues.
2. Failure to maintain the boundaries of normal tissues among organs.
3. Microscopic appearance which may resemble immature rather than mature tissues.
4. The risk of having the malignant cell spreading to parts of the body far from the place of origin.

Studies of the spatial variability of cancers are thus complicated by a wide variety of differential occurrence rates recorded by histological site.[4] In addition, different rates by site have been attributed to differences in sex, race, place of residence, individual behavior, specific environment, and many other non-medical traits.[5]

Not all cancer is fatal. In 1971 there were approximately 2,922,000 people alive with a history of cancer, and 39,000 people were alive who had stomach cancer.[6] In studying the different types of cancer, most cancer researchers are impressed with the differences among various kinds. At the present time, there are about 100 different types of cancer which

have been classified under the laboratory microscopes.[7]

## Cancer Over Time

In 1900 pneumonia and influenza were the leading causes of death in the United States and cancer ranked eighth (Table I). But, a rapid increase in the death rate from cancer occurred between 1900 and 1930. Mortality statistics for the entire United States were not available before 1933. This increase of cancer deaths was attributed to the changing composition of the population and to improved methods of diagnosis and case findings.[8]

In the 1970s, cancer is the second most frequent cause of death in the United States, accounting for 356,055 deaths in 1973. In 1975, 716,215 people died of cancer accounting for 336.2 per 100,000 population (Table II). For the past 30 years more men than women have died of cancer, furthermore half of all cancer deaths were in persons over 65.[9]

## Historical Trends in Cancer

Cancer is not a new disease it has been known for centuries. The disease was recognized in Egypt and in both the Smith and Ebeis papyri written in 1500 B.C.[10] Hippocrates gave the first well defined description of cancer and advanced many medical theories about its cause. Hippocrates believed that the body was composed of four fluids: blood, mucus, yellow bile, and black bile. Cancer was caused due to black bile. Also, Hippocrates' writing, "On Air, Water, and Place of Residence,"[11] recognized the relationship of man's physical environment and cancer. His teachings on the influence of the environment on people contains a

TABLE I

LEADING CAUSES OF DEATHS IN THE UNITED STATES, 1900

| | Rate per 100,000 | Percent of Deaths From All Causes |
|---|---|---|
| 1. Pneumonia/Influenza | 202 | 11.8 |
| 2. Tuberculosis | 194 | 11.3 |
| 3. Gastro-enteritis | 143 | 8.3 |
| 4. Heart Disease | 137 | 8.0 |
| 5. Cerebral Hemmorrhage | 107 | 6.2 |
| 6. Nephritis | 81 | 4.7 |
| 7. Accidents | 72 | 4.2 |
| 8. Cancer (All Sites) | 64 | 3.7 |
| 9. Diseases of Infancy | 63 | 3.6 |
| 10. Diptheria | 40 | 2.3 |

Source: U.S. National Center for Health Statistics, Vital Statistics of the United States

TABLE II

LEADING CAUSES OF DEATH AMONG AMERICANS, 1975

| | Number of Deaths | Death Rate Per 100,000 Population |
|---|---|---|
| 1. Heart Disease | 1,892,879 | 888.5 |
| 2. Cancer | 716,215 | 336.2 |
| 3. Stroke | 365,693 | 171.7 |
| 4. Accidents | 103,030 | 48.4 |
| 5. Influenza-Pneumonia | 55,664 | 26.1 |
| 6. Diabetes Mellitus | 35,230 | 16.5 |
| 7. Cirrhosis of Liver | 31,623 | 14.8 |
| 8. Arteriosclerosis | 28,887 | 13.6 |
| 9. Suicide | 27,063 | 12.7 |
| 10. Diseases of Early Infancy | 26,616 | 12.5 |
| All Other Causes | 308,820 | 144.9 |

Source: United States Public Health Service, 1975.

great deal of truth and his was also the first attempt to combine the study of disease and geography.

During the development of the understanding of cancer, many years went by before medical practitioners started to research what causes cancer. Percival Potts, one of the first cancer epidemiologists, described chimney sweep's cancer believing it was caused by soot. This was done in 1777 in London, England. As research in the medical field progressed, there was little known about the amount of mortality since records of this sort were not kept and, it was difficult to even visualize the number of deaths. The beginning of epidemiology had an important impact on the etiology of cancer. Better methods of research began to find clues as to the causes of cancer. The cost of cancer research today has gone well into the million of dollars. But the research has been one of the most important contributions to the welfare of mankind and hopefully as the saying goes "we want to wipe out cancer in our lifetime."[12]

## Geographical Variability of Stomach Cancer

Stomach cancer mortality reveals geographical differences in the amount of deaths from one state to another. The use of geographical studies has been one of the most productive of all techniques in revealing aetiological factors.[13] The variation in stomach cancer will be determined by the total number of deaths in each state divided by the population of the state (rate) for a one year period (January 1 to December 31). Mortality rates give the best indication of regional variation in the United States. The process for gathering mortality statistics is gathered first of all within the state. Each death is

recorded on a death certificate and is sent on to the National Center for Health Statistics for compilation. Throughout the thesis it must be kept in mind that the major source of error in mortality rates is the inaccurate determination of cause of death. The greatest reward expected from geographical studies on any type of cancer is a separation of environmental from intrinsic influences and an indication of what these influences might be. Because of the numerous possibilities in determining the geographical factors, this is not simple and good detective work is required.[14]

## Limitation of Mortality Data

Before this thesis goes any further there must be several explanations concerning the accuracy of mortality data. There are many problems inherent in the use of mortality data and the following are some:[15]

1. Differences in accuracy and completeness of medical information on death certificates.
2. Availability of physicians and specialized diagnostic services within different areas.
3. Accuracy of the population estimates.
4. Small number of deaths resulting in greater sampling variability.
5. Use of different classification systems in different locations.
6. Changing classification systems with time.

Some of these problems may not be related to stomach cancer but the data accuracy for mortality is questionable.

## Statement of the Problem and Hypotheses

At the beginning of the 1900s, stomach cancer was the leading cause of death from cancer in the United States. Very little was known concerning the geographical pattern of stomach cancer. However, knowing where stomach cancer prevails will aid in understanding the patterns over time. This thesis can help bring to light the changing patterns of stomach cancer. The problem is to find what geographical variables correlate with stomach cancer. The factors that will be tested are demographic, occupational, and socioeconomic variables.

The hypothesies that will be tested are:

1. There are latitudinal differences in stomach cancer patterns in the United States. The northeastern and north central states will have higher rates.
2. There are international variations of stomach cancer.
3. Stomach cancer will correlate higher with demographic and occupational variables than with socioeconomic variables.

The first two hypotheses will be tested by the use of maps and the third hypothesis will be tested by using statistical analysis.

## Methodology

To describe the pattern of stomach cancer mortality by state, the first step will be to establish an index which helps to categorize each state. The following statistic will be used to create the index:

$$\frac{\text{Cause of Death}}{\text{Population at Risk}} \times 1000 = \text{deaths per } 100{,}000$$

where Cause of Death is stomach cancer,

where Population at Risk is the mid-year resident population (July 1),

where 100,000 will be the constant multiplier for deaths per 100,000 population in each state.

The analysis of stomach cancer for the entire United States will be explained by demographic, occupational, and socioeconomic variables for 1940 to 1973. The most convenient test for testing stomach cancer in the United States is multiple regression.[16] The assumption is that stomach cancer is the dependent variable acted upon by a variety of independent socioeconomic and demographic variables on the state basis, this in turn can be used to describe the United States.

## Objectives

The primary objective of this thesis is to analyze the trends of stomach cancer and the demographic, occupational, and socioeconomic variables which may affect the rate of stomach cancer in the United States. Also, the thesis will explain the ethnic factors, physical environment, and occupational factors which attribute to stomach cancer. The following chapters will attempt to answer the above objectives. Chapter II will review the pertinent literature on stomach cancer and explanations of various research of other cancers which are geographic in nature and statistical techniques which are used. Chapter III will present a discussion on the historical-geographical trends of stomach cancer in the United States and a review of international variations of stomach cancer through time. Chapter IV is the analysis chapter testing the independent variables against stomach cancer in

the United States from 1940-1973, and Chapter V will discuss the role of the medical geographer in cancer research. Also, Chapter V will summarize the thesis findings. A glossary will be added to supplement the medical terminology which will be used from time to time.

FOOTNOTES

[1]Paul E. Steiner, "Epiemiology of Cancer," Cancer, Vol. 3 (1958), p. 174.

[2]Progress Against Cancer of the Stomach, National Cancer Institute, 1975, p. 2.

[3]Gerald F. Pyle, Heart Disease, Cancer, and Stroke in Chicago, The University of Chicago, Department of Geography Research Paper 134 (Chicago, 1971), p. 43.

[4]Ibid., p. 46.

[5]Ibid.

[6]David L. Levin et al., Cancer Rates and Risks (2nd ed., Washington, 1974), p. 5.

[7]Ibid., p. 7.

[8]Harold F. Dorn, "Cancer Mortality Trends in the United States," Cancer, Vol. 3 (1958), p. 209.

[9]David L. Levin et al., Cancer Rates and Risks (2nd ed., Washington, 1974), p. 4.

[10]American Cancer Society, Cancer: A Manual for Practitioners (2nd ed., Boston, 1950), p. 1.

[11]Folke Henschen, The History and Geography of Diseases (New York, 1962), pp. 17-18.

[12]Quotation from the American Cancer Society.

[13]Paul E. Steiner, "Epidemiology of Cancer," Cancer, Vol. 3 (1958), P. 177.

[14]Ibid.

[15]Gary R. Newell, "Cancer Mortality and Environmental Temperature in the United States," The Lancet, Vol. 11, No. 7650 (1970), pp. 760-768.

[16]A. T. A. Learmonth, "Ecological Medical Geography," Progress in Geography, Vol. 7 (1975), pp. 201-226.

# CHAPTER II

## LITERATURE REVIEW

One of the major advantages of medical geography research is the abundancy of literature in biological and medical journals. In order to become proficient in obtaining the necessary research materials, the medical geographer must become familiar with as much of the literature as possible in order to understand the significance of diseases. The disadvantge of medical geography research is the scarcity of literature in the professional geographic journals. The main reason for this is that there are only a few geographers who are actively involved in medical geography and a few other geographers who have a peripheral interest.[1] After all, the themes that geographers study seem almost infinite in variety.[2]

Cancer has become a growing concern to all who have encountered the disease and to the medical researchers who are trying to find a cure or attempts to control a specific cancer. Recently the National Cancer Institute has come out with new reports indicating certain cancer has increased during the past year. This chapter will concentrate on two areas of literature on the geographic distribution of cancer. The first area will review pertinent literature on cancer as a research field using geographic concepts and the second area will review the literature on the geography of stomach cancer.

## Geography and Cancer

The most comprehnsive spatial display on cancer at the national level was done by Fred Burbank, Patterns in Cancer Mortality in the United States: 1950-1971, (1971).[3] Burbank deals with cancer mortality rates according to more than thirty different cancer sites.[4] Each category was analyzed by sex and race; graphs of age-specific rates, graphs of mortality rate change overtime, computerized maps of static geographic distributions and maps of dynamic geographic distributions. The static geographic distributions reflect the amount of variation of the observed mortality from the expected rate for that particular cancer death category. The dynamic geographic distributions show time trends in the state age-adjusted death rates. This represents the change in mortality rate of each state relative to the trend change in the remaining states. From reviewing the atlas, it was possible to observe the degree to which a state's mortality rate was increasing or decreasing over the study period from 1950-1967. Burbank did not explain the reasons for the cause and effect of the cancer pattern relating to all cancer sites. It was based solely upon statistical correlation for each state.

In Burbank's study, stomach cancer was concentrated throughout the Eastern United States, extending westward through Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota. These states had a higher incidence of stomach cancer mortality as compared to the other states.

Another important publication at the national level on cancer was done by the National Cancer Institute which studied the geographic patterns of cancer mortality by county for each state from 1950-1969.[5]

This research helped to visualize geographic variation of cancer patterns by cancer types. The maps helped to identify counties or clusters of counties which are high or low risk cancer areas. The pattern for stomach cancer shows an extensive cluster of high stomach cancer mortality throughout northern Minnesota, northern Wisconsin, northern Michigan, and the Dakotas.[6] High mortality rates were observed in counties of northeastern Maine, northcentral New Mexico, and Southern Colorado. The geographic pattern for stomach cancer was influenced strongly by ethnic factors.[7] The cluster of mortality in male and female in the north central states was closely correlated with the geographical concentration of persons from Austria, the Soviet Union, and Scandinavia.[8] From this cancer atlas the National Cancer Institute published a county by county numeric atlas which showed the total number of deaths for each cancer site from 1950-1969. It specifically outlined the total deaths for state and county and age-adjusted death rates for white male, white female, nonwhite male, and nonwhite female. This publication would be helpful if the study involves a smaller unit of study such as the county.

From the NCI atlas, U.S. Cancer Mortality by County: 1950-1969,[9] the National Cancer Institute published a series of journal articles relating to cancer sites from the atlas and furthered the investigation for the reasons of such a geographic pattern. Bladder cancer was studied for the same time period as the atlas by Blot and Fraumeni.[10] Bladder cancer was correlated with demographic variables, socioeconomic variables, and certain industrial indexes. Multiple regression was used to find if there was any significant correlation between bladder cancer and the tested variables. Socioeconomic variables indicated a small but

a positive gradient, mortality was slightly higher among males in counties with a high percentage of British and German residents.[11] The industrial indexes revealed a high bladder cancer mortality in counties where chemical industries are located. This study did provide important etiological clues and also explained the consistent patterns that are helpful for further investigation.

Another study by the NCI (Blair and Fraumeni) attempted to explain the geographic patterns of prostate cancer in the United States.[12] Demographic, industrial, and agricultural variables were used to find correlations with prostate cancer mortality. The study found a small amount of geographic variation across the United States. There was a substantial variation paralleled by ethnic correlations. The ethnic factor was strong in counties with Scandinavian ancestry, Swedish, Norwegian, and Danish ancestry, and also a factor in regional foodways of the counties. The technique which was used was Pearsonian correlation-coefficients and Analysis of Variance. Other factors which were found relating to the spatial pattern of prostate cancer were counties having metal using textile industries and regions with high consumption of high fat foods.

In a study done on the United States, age-adjusted cancer death rates were applied to a 20 year period between 1940-1959 and strong regional patterns were found in the level of death rates and in their variation over time by MacDonald, Wellington, and Wolf.[13] By using correlation analysis, relationships between various sites of cancer with respect to their regional mortality patterns were derived. The regional differences were primarily due to racial composition.

In a study done by Michael Shimkin, he explains how geographic

variations in cancer patterns can be understood.[14] He explained that cancer sites can vary with age structure, sex, race, and nationality. Shimkin also indicates differences relating to socioeconomic status. In his study, Shimkin ranked five groups in accordance with education, income, occupation, race, and residential location. From the socioeconomic ranks, cancer mortality rates were compared with the rankings. The study found more cancer among the lower classes and the cancer rate decreased with increase status. Relationship of different cancer sites may relate to differences in occupation since many of the lower status jobs will expose workers to carcinogenic elements.

At the urban level of study, Graham, Levin, and Lilienfield developed a socioeconomic gradient in Buffalo, New York for the period of 1948-1952.[15] Cancer statistics were reported for various economic groups having a specific type of cancer. Their analysis developed the following findings:

1. Male patients; there was an increasing incidence with decreasing socioeconomic status for cancer of the stomach, esophagus, liver, lung, and larynx.
2. Female patients; there was an increasing incidence with decreasing socioeconomic status for cancer of the stomach, liver, and cervix.[16]

## Geography and Stomach Cancer

The purpose of the second part of this chapter is to look at the literature pertaining to stomach cancer. The literature concerning journals in geography is limited and there is a need to look at articles which have a geographic approach to understanding the occurrence of stomach cancer patterns.

In 1954, Dr. Edward Cohart analyzed the socioeconomic distribution of stomach cancer in New Haven, Connecticut.[17] The author studied stomach cancer incidence during 1935 to 1949. Each of the 658 reported cases of stomach cancer were assigned on the basis of residence to one of 25 districts. These districts were grouped into seven homogeneous socioeconomic areas arranged in sequential order from rich (A) to poor (G) according to the socioeconomic criteria employed.[18] The differences between observed and expected rates were examined for statistical significance. The chi-square test was used to determine the significance of the observed differences.

The outcome of the Cohart study suggests that there is significant associations between the socioeconomic status of New Haven residents and the incidence of stomach cancer. With this accepted hypothesis, there was the possibility of certain leads for investigation aimed at discovering specific etiological cancer causing agents.

The relationship of suspended particulate air pollution to stomach cancer mortality was studied for two years (1961-1963) in Buffalo, New York.[19] Suspended particulate levels were determined by high volume samplers located at 21 sampling stations randomly scattered over the study area. Buffalo was classified into five economic areas on the basis of median family income of each census tract. Mortality rates for stomach cancer in white males and females, 50 to 64 years of age population were almost twice as high in areas of high suspended particulate air pollution in Buffalo. This association appeared to be independent of the effect of economic status and not attributable to the ethnic distribution of the study area population.[20]

Malcolm Murray who is a medical geographer, studied in 1962 The

Geography of Death in England and Wales,[21] discussed the mortality rates of malignant neoplasms of the stomach from 1950 to 1953. Also Murray mapped the death rates of malignant neoplasms of the trachea, lung and bronchus, and diseases of the cardiovascular system. From the map on stomach cancer, Standardized Mortality Ratios (SMR) were used to categorize the mortality data. The spatial pattern for stomach cancer showed a high mortality toward the North and West of England and Wales. Wales was extremely high in stomach cancer mortality. G. Melvyn Howe suggested a positive relationship with runoff from the tailings from the abandoned mines in Wales.[22] This water runoff contains high toxic chemicals and may be carcinogenic when ingested over a period of time. Another assumption for this high mortality area was the high consumption of fried foods and the reuse of cooking fats.

G. Melvyn Howe also looked at stomach cancer patterns (1959-1963) in the United Kingdom.[23] He also studied the geography of lung-bronchus and showed the areas where these chronic diseases are located. The areal distribution for stomach cancer suggests that environmental factors may contribute to the development of certain cancers. Howe postulated that a range of factors existed as being associated with stomach cancer patterns in the United Kingdom. These factors are spoil heaps and the workings of abandoned lead, zinc, and copper mines in Britain.

N. D. McGlashan uses statistical and cartographic methodology in a short article entitles "European Male Stomach Cancer in South Africa: A Cartographic Appraisal."[24] McGlashan addressed the problem of data collection in enumeration districts of different sizes and containing wide variations in the population at risk. The method employed was using mortality rates, standard deviation measures, and also indicated

the significance of high and low mortality areas.

A. V. Chaklin, a Russian geographer, explained the development of cancer in the Soviet Union by applying geographic techniques to better understand it. Chaklin explained where stomach cancer occurs in Russia and the causes that would attribute to the death rate. Among the contributing factors were eating habits of the population, particularly the frequent use of overfried foods in certain areas of Russia. Also the heavy use of dairy products, vegetables, and fruits in southern Russia and certain meats in the mountain region.[25]

The techniques which are used by medical geographers to study the patterns of mortality is the choice of the medical geographer. The three methods which are usually used for statistical mapping are the crude death rate, age-adjusted death rate, and the Standardized Mortality Rate. By using these methods the nature of the distribution of rates intended for mapping are determined. An article by R. W. Armstrong, "Standardized Class Intervals and Rate Computation in Statistical Maps of Mortality," appearing in the Annals of the Association of American Geographers discussed the choice of categories for cartographic display of mortality data.[26] Armstrong was concerned with how to approach the problem of mapping mortality data. He explained the use of the standard deviation for properly setting up the mapping categories. He used the United States and Illinois to give an example of how to use the standard deviation. From these two comparisons he also mentioned the crude rate and the age adjusted rate and how these two statistics can change the interpretation of the spatial pattern.

Yola Verhasselt wrote an article on the problems related to research in geography and cancer.[27] Verhasselt mentions the difficulties

encountered in medical geography research is the availability of reliable statistical data, difficulty of explaining distribution patterns from mapping, and the complexity and interaction of environmental factors. Also he mentions a better understanding is needed for studying migrant populations. The comparison of cancer incidence between migrants and indigenous groups may reveal important epidemiological factors.

The field of medical geography applies geographic concepts and statistical techniques to the study of cancer which are spatially distributed. This thesis is designed to study stomach cancer in order to discover some of the "whys" and "wheres" of this disease by using some of the ideas the authors have used in this second chapter.

FOOTNOTES

[1]John M. Hunter, The Geography of Health and Disease (Chapel Hill, 1974), p. 112.

[2]Ibid.

[3]Fred Burbank, Patterns in Cancer Mortality in the United States: 1959-1967, National Cancer Institute Monograph 33 (Washington, 1971).

[4]T. J. Mason and F. W. McKay, U.S. Cancer Mortality by County, 1950-1969, Department of Health, Education, and Welfare Publication No. (NIH) 74-615 (Washington, 1973).

[5]Ibid.

[6]Ibid.

[7]Ibid.

[8]Ibid.

[9]Ibid.

[10]W. J. Blot and Joseph Fraumeni, "Geographic Patterns of Bladder Cancer in the United States," Journal of the National Cancer Institute, Vol. 61, No. 4 (October, 1978), pp. 1017-1023.

[11]Ibid., p. 1022.

[12]Aron Blair and Joseph F. Fraumeni, "Geographic Patterns of Prostate Cancer in the United States," Journal of the National Cancer Institute, Vol. 61, No. 6 (December, 1978), pp. 1379-1384.

[13]Eleanor J. MacDonald, Dorothy Gaites Wellington, and Patricia F. Wolf, "Regional Patterns in Mortality From Cancer in the United States," Cancer, Vol. 20 (May, 1967), pp. 617-622.

[14]Michael B. Shimkin, "Distribution of Cancer in the United States," Archives of Environmental Health, Vol. 16 (April, 1968), pp. 503-512.

[15]Saxon Graham, David Levin, and Abraham Lilienfield, "The Socio-economic Distribution of Cancer of Various Sites in Buffalo, 1948-1952," Cancer, Vol. 13 (1960), pp. 180-191.

[16]Ibid., p. 190.

[17]Edward M. Cohart, "Socioeconomic Distribution of Stomach Cancer in New Haven, Connecticut," Cancer, Vol. 7 (1954), pp. 455-461.

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[19]Warren Winkle, Jr. and Seymour Kanton, "Stomach Cancer: Positive Association with Suspended Air Pollution," Archives of Environmental Health, Vol. 18 (April, 1969), pp. 544-57.

[20]Ibid.

[21]Malcolm A. Murray, "The Geography of Death in England and Wales," Annals, Association of American Geographers, Vol. 52 (1962), pp. 13-149.

[22]Ibid., p. 133.

[23]Melvyn Howe, "The Geography of Lung Bronchus and Stomach Cancer in the United Kingdom," Scottish Geographical Magazine, Vol. 87, No. 3 (1971), pp. 202-220.

[24]N. D. MacGlashan, "European Male Stomach Cancer in South Africa: A Cartographic Appraisal, in N. D. MacGlashan (ed.), Medical Geography and Field Techniques (London, 1972), pp. 188-195.

[25]A. V. Chaklin, "The Geographical Distribution of Cancer in the Soviet Union," Soviet Geography, Vol. 3 (October, 1962), p. 66.

[26]R. W. Armstrong, "Standardized Class Intervals and Rate Computation in Statistical Maps of Mortality," Annals, Association of American Geographers, Vol. 59 (June, 1969), pp. 382-390.

[27]Yola Verhasselt, "Notes on Geography and Cancer," Social Science and Medicine, Vol. 11 (1977), pp. 745-748.

[28]Ibid., p. 747.

# CHAPTER III

# HISTORICAL GEOGRAPHICAL PATTERNS OF STOMACH CANCER

## Introduction

In order to understand the spatial variation in the magnitude of stomach cancer, there is a need to look at the trends in the United States as well as trends at the international level. Mortality statistics permit comparisons to be made with a number of other countries which publish similar results. Contemporary death rates are available both in the published statistics for countries as well as in compilations issued by the World Health Organization (WHO).[1] There has been a great deal of etiological research outside the medical profession in attempting to find the causes of cancer for all sites and depicting the variation of cancer throughout the world. International variations are often striking and will provide clues to environmental and ethnic factors of stomach cancer. The geography of stomach cancer is global and there are numerous factors that will determine the spatial pattern of stomach cancer in the United States and for various countries of the world.

It must be kept in mind that the accuracy and completeness of mortality statistics will vary from country to country. The reliability of the comparisons made is solely dependent upon the accuracy of the data and this cannot be accurately assessed.[2] This chapter will look at the

trends in the United States from 1900 to 1973 using every five years for analysis. The first time period will cover the beginning of the death registration states from 1900 to 1930. The second time period will cover the years from 1930 to 1950 since all of the contiguous states after 1933 were part of the death registration states. The period from 1950 to 1969 will be of special interest because of the data availability of age-adjusted death rates. The final time period in the United States will be from 1970 to 1973. The second half of Chapter III will briefly scan the spatial patterns of stomach cancer at the international level. This section will rely more on previous research in explaining what countries have a higher mortality from stomach cancer.

Throughout this chapter, especially for the United States, the reader must be aware of a number of pitfalls that might be encountered concerning the interpretation of the spatial patterns. At this level of mapping any detailed interpretation of the patterns portrayed would be both inappropriate and presumptuous.[3] Any interpretation of the stomach cancer mortality pattern is obviously premature, and yet speculation is irresistable. It is permissable if the reader realizes the sensitivity limits of the mapping approach at this scale with the type of data available will allow for only cursory cause and effect conclusions.[4]

## Stomach Cancer in the United States: 1900-1930

With the establishment of the United States Death Registration area in 1900, continuous reporting of cancer mortality began in this country.[5] During this time only seven cancer sites were reported to

the Bureau of the Census. Mortality statistics for the entire United States were not available until 1933.[6] Stomach cancer is part of the digestive system which accounted for a larger portion of cancer deaths than any other cancer site group.[7] Since 1900 revisions of the International List of Causes of Death have been used to classify stomach cancer. The general effect of the revisions has been to improve the scope of the definition of stomach cancer as well as for other cancer sites.[8] Perhaps more important than any other factor affecting the comparability and reliability of stomach cancer mortality have been the improvements in the completeness and specificity of the causes of deaths correctly. Since the stomach is part of the digestive system the improved diagnosis of cancer has reduced the number of mortalities through time. During this time period, stomach cancer was combined with liver cancer for one cancer site group as specified by the International List of Causes of Deaths.

In 1900 there were only ten death registration states and they were mainly in the Northeastern United States. To show the gradual increase of the death registration states and death rates per 100,000 population, Tables III through VII will show the trends and the pattern starting to develop during the 30 year period. Between 1910 and 1925 a much larger number of states had been admitted to the registration area and trend of death rates from stomach and liver cancer can be examined in different geographic regions of the United States. The five regions during this time period were, according to the Bureau of the Census from 1910 to 1925, the Northeast, East North Central, South, West Central, and Pacific. The death registration states reported information on white people predominantly. The racial composition of the population may cause problems

TABLE III

1900 DEATH REGISTRATION STATES: DEATH RATES PER 100,000 POPULATION FROM STOMACH AND LIVER CANCER

| States | Deaths per 100,000 |
|---|---|
| Maine | 28.80 |
| Rhode Island | 27.53 |
| Vermont | 26.77 |
| New York | 24.46 |
| New Hampshire | 22.83 |
| Connecticut | 22.23 |
| Massachusetts | 21.85 |
| New Jersey | 20.65 |
| Indiana | 13.07 |
| Michigan | 8.26 |

TABLE IV

1910 DEATH REGISTRATION STATES: DEATH RATES PER 100,000 POPULATION FROM STOMACH AND LIVER CANCER

| States | Deaths per 100,000 |
|---|---|
| Northeast | |
| Vermont | 45.23 |
| Maine | 39.19 |
| New Hampshire | 34.53 |
| New York | 33.65 |
| Massachusetts | 32.81 |
| Maryland | 31.72 |
| Connecticut | 29.78 |
| Rhode Island | 28.93 |
| New Jersey | 33.65 |
| Pennsylvania | 27.37 |
| East North Central | |
| Wisconsin | 36.12 |
| Minnesota | 32.71 |
| Michigan | 31.27 |
| Ohio | 30.58 |
| Indiana | 29.17 |
| West Central | |
| Colorado | 23.04 |
| Montana | 19.94 |
| Utah | 15.26 |
| Pacific | |
| California | 34.44 |
| Washington | 23.99 |
| South | |
| North Carolina | 13.81 |

TABLE V

1915 DEATH REGISTRATION STATES: DEATH RATES PER 100,000 POPULATION FROM STOMACH AND LIVER CANCER

| States | Deaths per 100,000 |
|---|---|
| Northeast | |
| Maine | 39.73 |
| Vermont | 38.34 |
| New Hampshire | 35.86 |
| Massachusetts | 34.97 |
| New York | 34.71 |
| Maryland | 34.17 |
| Rhode Island | 33.18 |
| Connecticut | 32.64 |
| New Jersey | 31.99 |
| Pennsylvania | 29.96 |
| East North Central | |
| Wisconsin | 39.41 |
| Minnesota | 38.01 |
| Michigan | 35.81 |
| Indiana | 33.91 |
| Ohio | 32.81 |
| Missouri | 25.91 |
| West Central | |
| Kansas | 27.39 |
| Utah | 22.62 |
| Montana | 22.41 |
| Colorado | 22.12 |
| Pacific | |
| California | 39.91 |
| Washington | 23.52 |
| South | |
| North Carolina | 20.51 |
| Virginia | 19.29 |
| Kentucky | 17.05 |

TABLE VI

1920 DEATH REGISTRATION STATES: DEATH RATES PER 100,000 POPULATION FROM STOMACH AND LIVER CANCER

| States | Deaths per 100,000 |
|---|---|
| Northeast | |
| Vermont | 46.27 |
| Maine | 45.01 |
| New Hampshire | 41.24 |
| Connecticut | 37.86 |
| Massachusetts | 36.62 |
| Delaware | 36.59 |
| New York | 36.21 |
| Maryland | 35.06 |
| Pennsylvania | 33.17 |
| Rhode Island | 32.42 |
| New Jersey | 31.43 |
| East North Central | |
| Wisconsin | 41.66 |
| Minnesota | 42.36 |
| Illinois | 36.48 |
| Indiana | 34.93 |
| Ohio | 34.62 |
| Michigan | 34.12 |
| Missouri | 30.64 |
| West Central | |
| Nebraska | 33.57 |
| Colorado | 31.36 |
| Kansas | 27.08 |
| Utah | 25.14 |
| Montana | 19.00 |
| Pacific | |
| California | 40.85 |
| Washington | 34.36 |
| Oregon | 35.78 |

TABLE VI (CONTINUED)

| States | Deaths per 100,000 |
|---|---|
| South | |
| Kentucky | 20.63 |
| Virginia | 18.43 |
| Florida | 17.66 |
| Louisiana | 14.30 |
| North Carolina | 13.03 |
| Tennessee | 12.74 |
| Mississippi | 11.17 |
| South Carolina | 10.39 |

TABLE VII

1925 DEATH REGISTRATION STATES: DEATH RATES PER 100,000 POPULATION FROM STOMACH AND LIVER CANCER

| States | Deaths per 100,000 |
|---|---|
| Northeast | |
| Maine | 48.28 |
| New Hampshire | 47.56 |
| Vermont | 47.38 |
| New York | 41.06 |
| Massachusetts | 40.32 |
| Maryland | 38.39 |
| New Jersey | 36.69 |
| Connecticut | 36.00 |
| Rhode Island | 35.33 |
| Pennsylvania | 35.22 |
| Delaware | 25.63 |
| East North Central | |
| Wisconsin | 46.59 |
| Iowa | 41.86 |
| Minnesota | 41.74 |
| Illinois | 39.24 |
| Indiana | 37.99 |
| Ohio | 35.68 |
| Missouri | 35.39 |
| Michigan | 34.45 |
| West Central | |
| Nebraska | 36.54 |
| Kansas | 33.75 |
| Colorado | 33.17 |
| North Dakota | 32.75 |
| Idaho | 27.45 |
| Utah | 27.38 |
| Montana | 22.32 |
| Wyoming | 19.21 |
| Pacific | |
| California | 45.16 |
| Oregon | 40.67 |
| Washington | 37.21 |

TABLE VII (Continued)

| States | Deaths per 100,000 |
|---|---|
| South | |
| West Virginia | 22.77 |
| Kentucky | 21.13 |
| Virginia | 21.08 |
| Louisiana | 21.05 |
| Florida | 20.49 |
| Tennessee | 16.66 |
| North Carolina | 15.46 |
| Mississippi | 15.19 |
| Alabama | 13.00 |
| South Carolina | 12.30 |

with the data. Changes have occurred since that time, and it probably has affected the death rate.

The most rapid increase in mortality from stomach and liver cancer occurred between 1900 and 1930.[9] This increase in stomach and liver cancer has been a subject of controversy to medical practitioners for years. For those who hold that the increase is only apparent maintain that improvements in diagnosis accounts for the increase in the recorded death rates, while the other side, admitting that recorded increase, still holds that there is an actual increase in the death rate. The analysis of these tables depicts the changing composition of the population and the result is a greater variation in death rates for separate states.[10] As more states joined the death registration area the newer states throughout the South and West Central regions had a very low death rate. The South did not have a large number of states in the death registration area from 1910 to 1915. It was not until 1920 that the majority of the southern states started to become members and the lower death rates were predominantly throughout the south. The increase in stomach and liver cancer rates can be seen in Table IV, Table V, Table VI, and Table VII. The tables show a predominate cluster of states in the Northeastern and East North Central regions. In the Northeastern region, Vermont, Maine. New Hampshire, and New York have a higher death rate than the rest of the states in the region. In the East North Central region, Wisconsin and Minnesota are high in death rates. The Pacific region has a high death rate and ranks as one of the leading geographic regions in the United States.

The mortality rate from stomach and liver cancer is definitely higher in the Northeast, East North Central, and Pacific regions. The

South and the rural Plains of the West North and South Central regions have lower death rates. Some of the excess in the recorded cancer death rates in the north and in the Pacific states may be due to better facilities for proper diagnosis of the disease. The fact that this cancer site shows different kinds of variation suggests that some geographic differences are real and cannot be explained by the accessibility of the site of the cancer. Another explanantion that has been mentioned concerning the differences between the north and the south is the number of physicians to the population and the lack of clinical and diagnostic facilities throughout the south. In summary for this time period, stomach and liver cancer were reported as one cancer site and had the highest death rate of any other cancer site. The emergence of the death registration states developed a north-south division with higher death rates throughout the northern region. In Table VIII, the number of deaths and death rates per 100,000 from stomach cancer according to SEAT of occurrence as specified by the International List of Causes of Death from 1915 to 1930 is shown. The table indicates an increase in stomach cancer mortality for the United States. During this time period not all of the states were part of the death registration area.

## 1930 - 1950

In 1930 the International List of Causes of Death changed the cancer site stomach and liver cancer to stomach and duodenum cancer (ICD 46, b, c).[11] The continued growth of the death registration states included the entire United States with the exception of Texas which was admitted in 1933. Between 1930 and 1950 there was a gradual decline in mortality assigned to this cancer site. The actual decline occurred

TABLE VIII

UNITED STATES DEATH REGISTRATION AREA
STOMACH CANCER: 1915-1930

| Year | Number of Deaths | Rate of 100,000 | Percentage of Stomach Cancer Deaths From All Cancer |
|---|---|---|---|
| 1915 | 13,656 | 20.2 | 25.0 |
| 1920 | 17,625 | 20.1 | 24.2 |
| 1925 | 22,665 | 22.0 | 23.7 |
| 1930* | 25,408 | 21.4 | 22.0 |

* (stomach-duodenum)

Source: Mortality Statistics, U.S. Department of Commerce, Bureau of the Census, Vol. 16 (1915), Vol. 21 (1920), Vol. 26, Part III (1925), 1930.

after 1945. Figures 1 through 5 show the variation from state to state in death rates from cancer of the stomach and duodenum from 1930 to 1950.[12] The highest rates from cancer of the stomach and duodenum are largely in the north and the lowest rates are in the south. In 1930 (Figure 1) there is a north-south division with the highest rates in the Northeastern states of Maine, New Hampshire, and Rhode Island and the North Central states of Minnesota, Wisconsin, and Iowa. From 1935 to 1950 (Figure 2, Figure 3, Figure 4, and Figure 5) the northern tier states extend, with few exceptions, from the Atlantic to the Pacific. The Southern states will usually have lower rates since the South is largely rural. This seems to substantiate the visual observation that in our culture, other factors being equal, life in the urban places of limited industry and a low density factor will have a lower mortality rate. The variation in death rates from state to state might be attributed somewhat to ethnicity. In the northern tier states of Michigan, Wisconsin, Minnesota, and the Dakotas, people of Austrian, Scandinavian, and German descent have settled in this area and a high death rate of stomach cancer is prevalent. Thus these groups of migrants are prone to stomach cancer and would be compatible with the high incidence of stomach cancer in their countries of origin. The high death rates in Colorado from 1930 to 1945 may be caused by the influence of the Spanish-Americans in the state. The higher rates in the densely populated areas of the Northeastern United States can be caused by industrialization and the concentration of certain ethnic groups. In spite of obvious failings, these maps do reveal a death rate pattern of some significance for the United States.

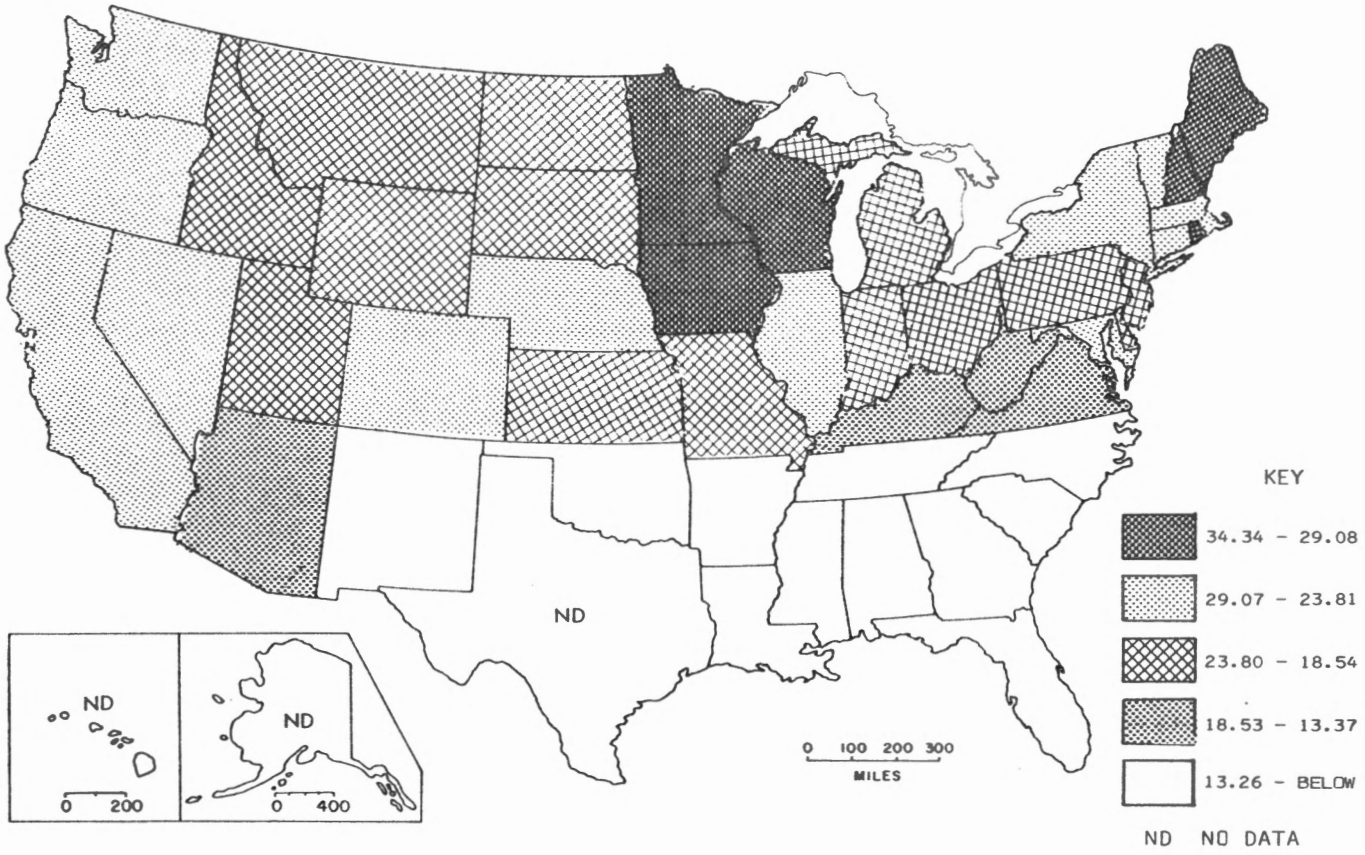



Figure 1. Stomach and Duodenum Cancer Death Rates Per 100,000 Population by State for 1930

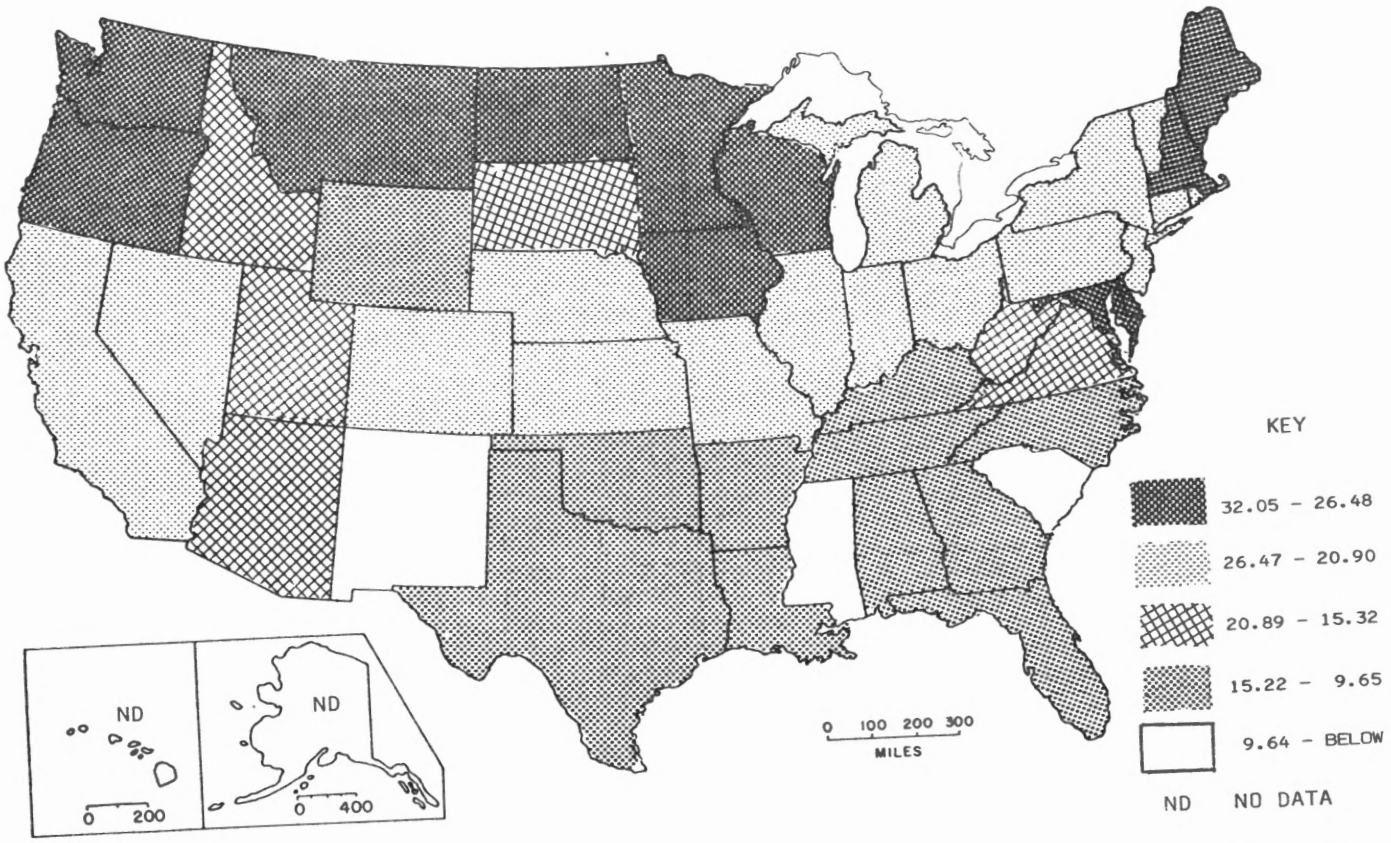



Figure 2. Stomach and Duodenum Cancer Death Rates Per 100,000 Population by State for 1935

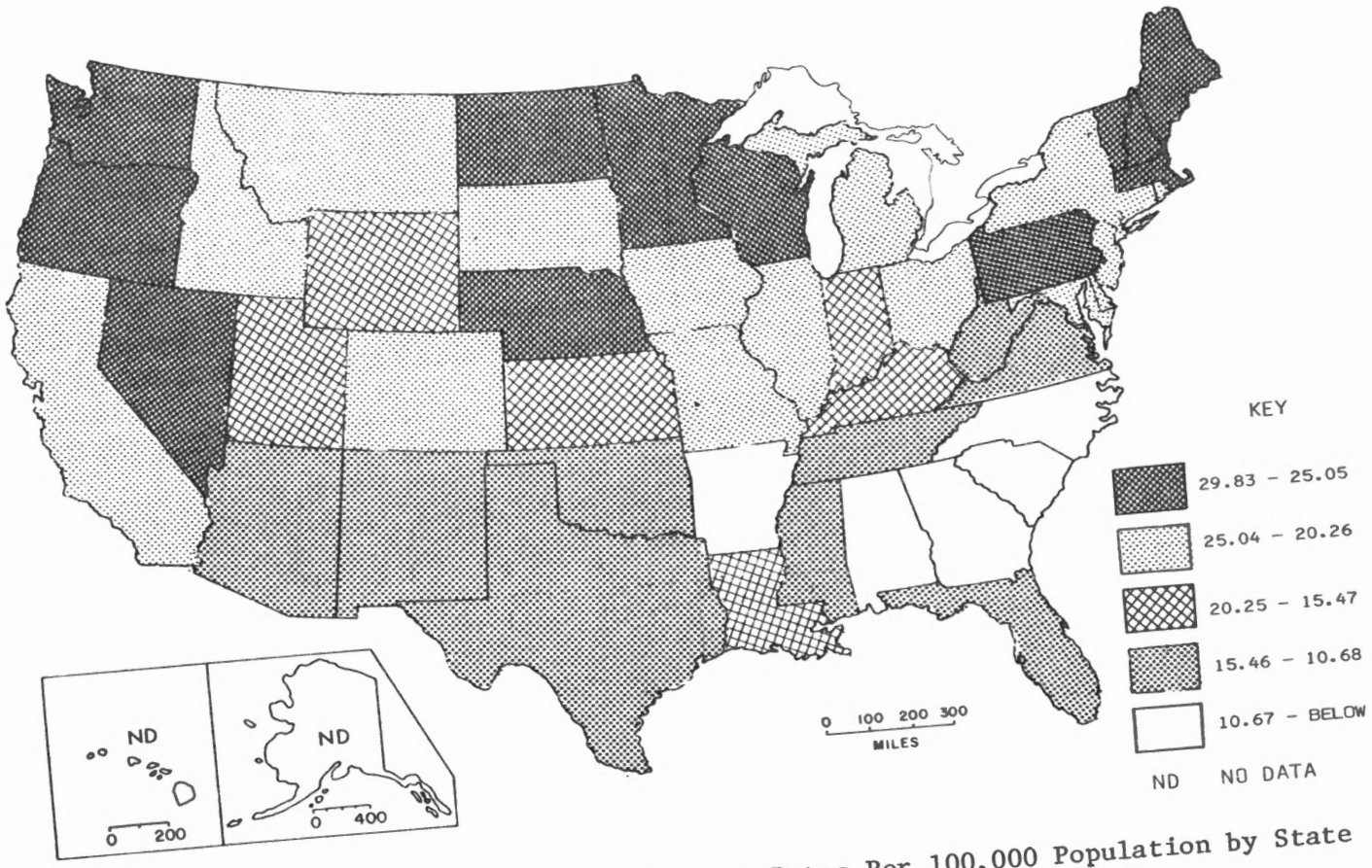



Figure 3. Stomach and Duodenum Cancer Death Rates Per 100,000 Population by State for 1940

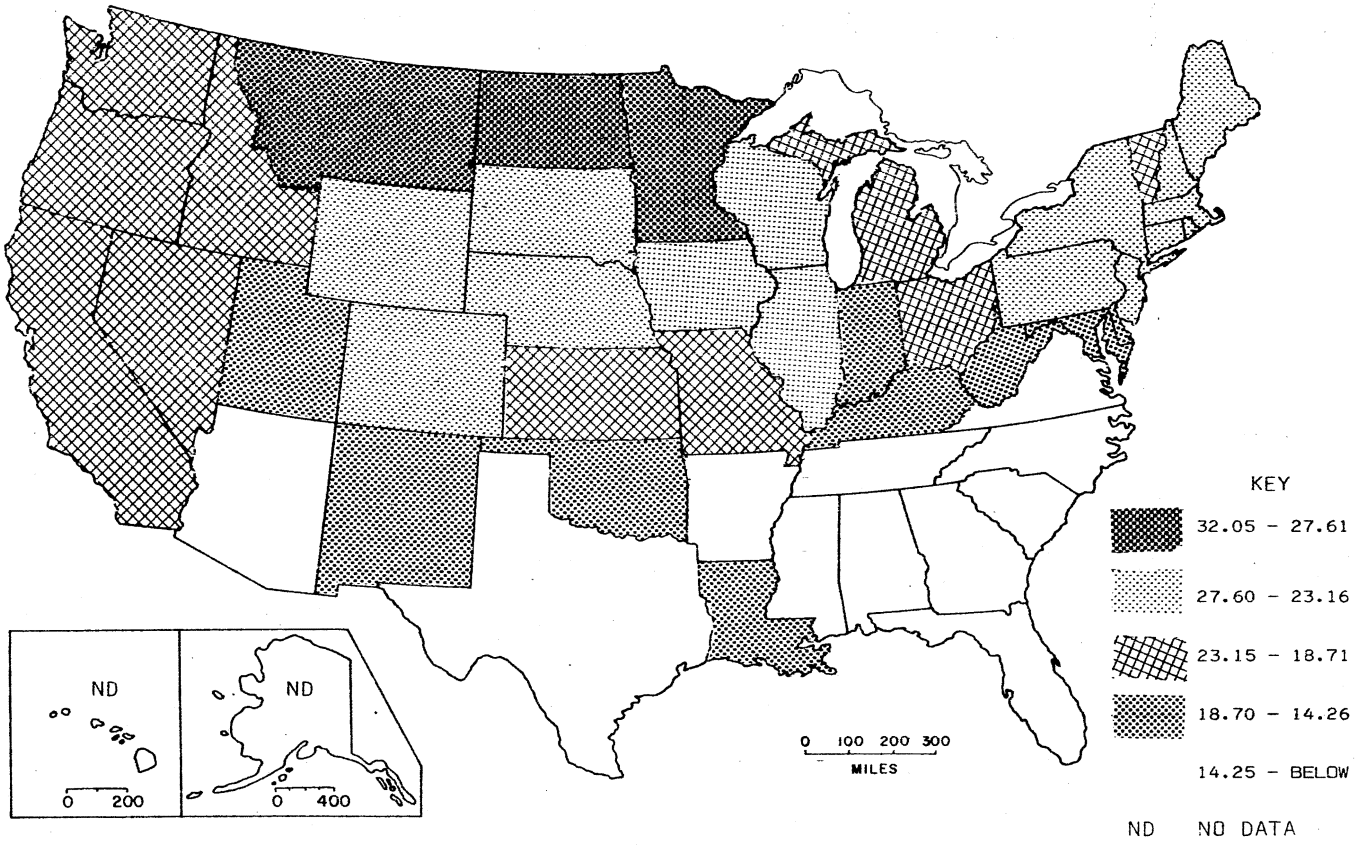



Figure 4. Stomach and Duodenum Cancer Death Rates Per 100,000 Population by State for 1945

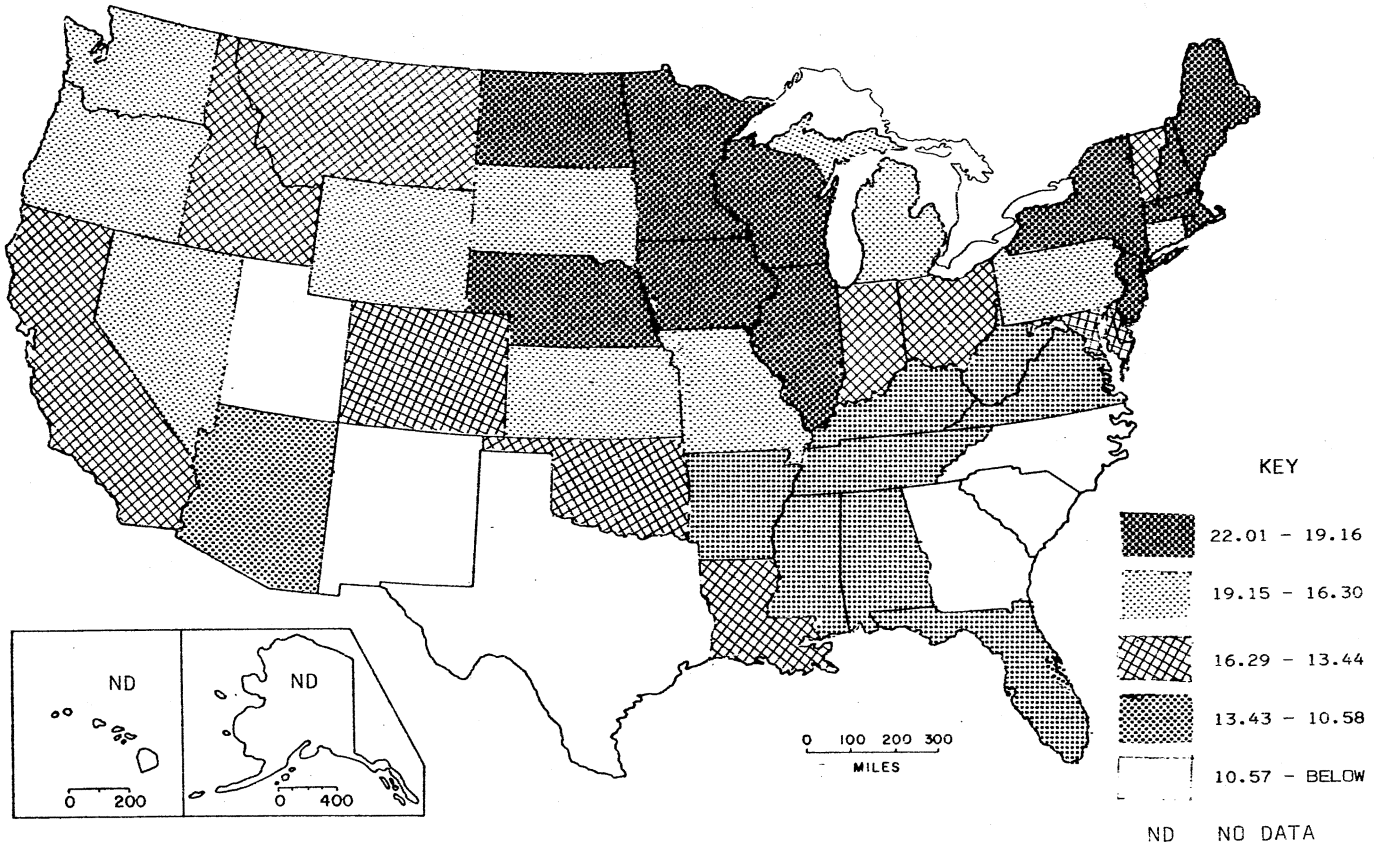



Figure 5. Stomach and Duodenum Cancer Death Rates Per 100,000 Population by State for 1950

## 1950 - 1969

Up to this point the study has relied on absolute figures and converted to deaths per 100,000 population to show the spatial pattern of stomach cancer. This time period (1950 to 1969) will use age-adjusted death rates to show how the geographic pattern will vary by adjusting for age and sex composition of the population. By adjusting for age and sex composition variations, it helps to place all states in a truer perspective. The age composition will vary from state to state and variation will occur since one state will have more older people than another state. The sex composition will vary since one state will have more females than other states and variation will also occur due to the marked differences in the male and female reproductive system.[13] The other differences will occur due to ethnic variations from state to state. Certain nonwhite groups are more prone to stomach cancer. Nonwhite includes American Indian, Chinese, Japanese, and persons of mixed Negro and other parentage.[14]

The data given in this time period were taken from the U.S. Cancer Mortality by County Atlas, 1950-1969.[15] The data were age-adjusted using 1950 as the standard population.[16] Age-adjusted death rates were computed for each state between 1950 and 1969. The total number of deaths were taken from state death certificates indicating the cause of death, sex, age, and race from which the patient died in.

It would be extremely difficult to explain why the spatial variations are the way they are for each state. The total number of deaths, age-adjusted for white and nonwhite population has varied considerably during this 20 year period. The demographic characteristics are different for each state and this would partially explain the differences

throughout the United States. Since 1950 the age-adjusted death rates are higher for nonwhites which includes the Negro as the dominant nonwhite population (Figure 6 and Figure 7). The stomach is one of the major sites where cancer risk is higher among Negroes. The nonwhite population has a high risk for stomach cancer and persists in all regions of the country. The rapid rise in reported stomach cancer mortality for the nonwhite population is partially a reflection of improvement in diagnosis and medical care which permits more accurate certification of death.[17] Other evidence suggest that part of the rise is real and may be related to exposure to levels of industrial and environmental pollutants associated with changes in occupation and life style.[18] Blacks have been exposed to environmental pollutants that have been linked to stomach cancer especially in the years after World War II.[19]

Another characteristic of the nonwhite population includes the Indian of the Mountain states.[20] This may account for the high rates for the nonwhite female in Idaho and Utah. Also the Western United States has about one-third of the Chinese and Japanese population. The spatial pattern shows Washington as a high risk state for stomach cancer mortality (Figures 8 and 9). Cooperative studies by the National Cancer Institute have indicated that the Japanese migrants to the United States have a higher than average risk of stomach cancer.[21] The northern regions, particularly those with major population centers have large foreign born population unlike the South where most of the population is native born of native parentage.[22] Part of the difference between the North and the South can be attributed by the higher stomach cancer rates among the foreign born.

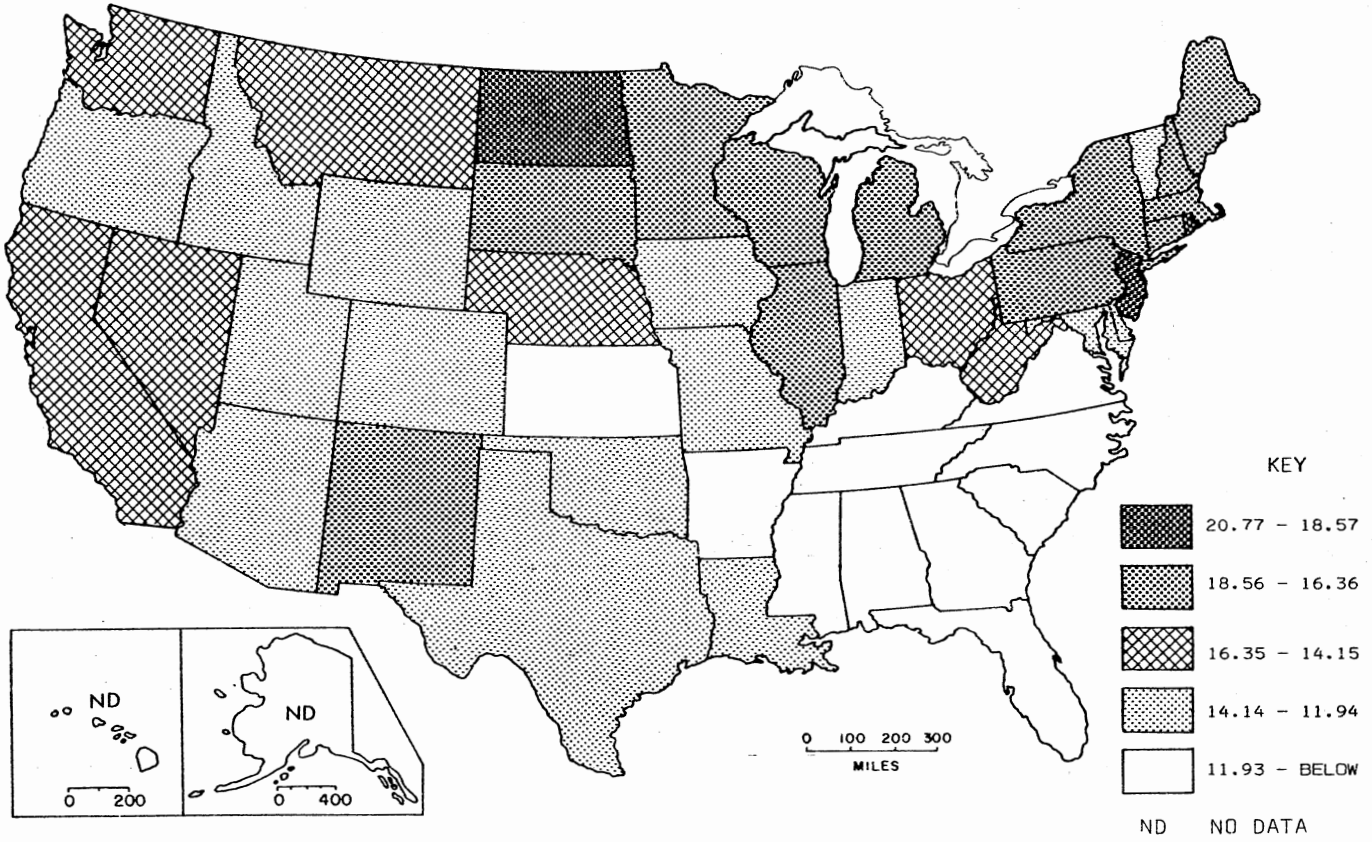



Figure 6. Stomach Cancer Death Rates Per 100,000 Nonwhite Male Population, Age-Adjusted by State: 1950-1969

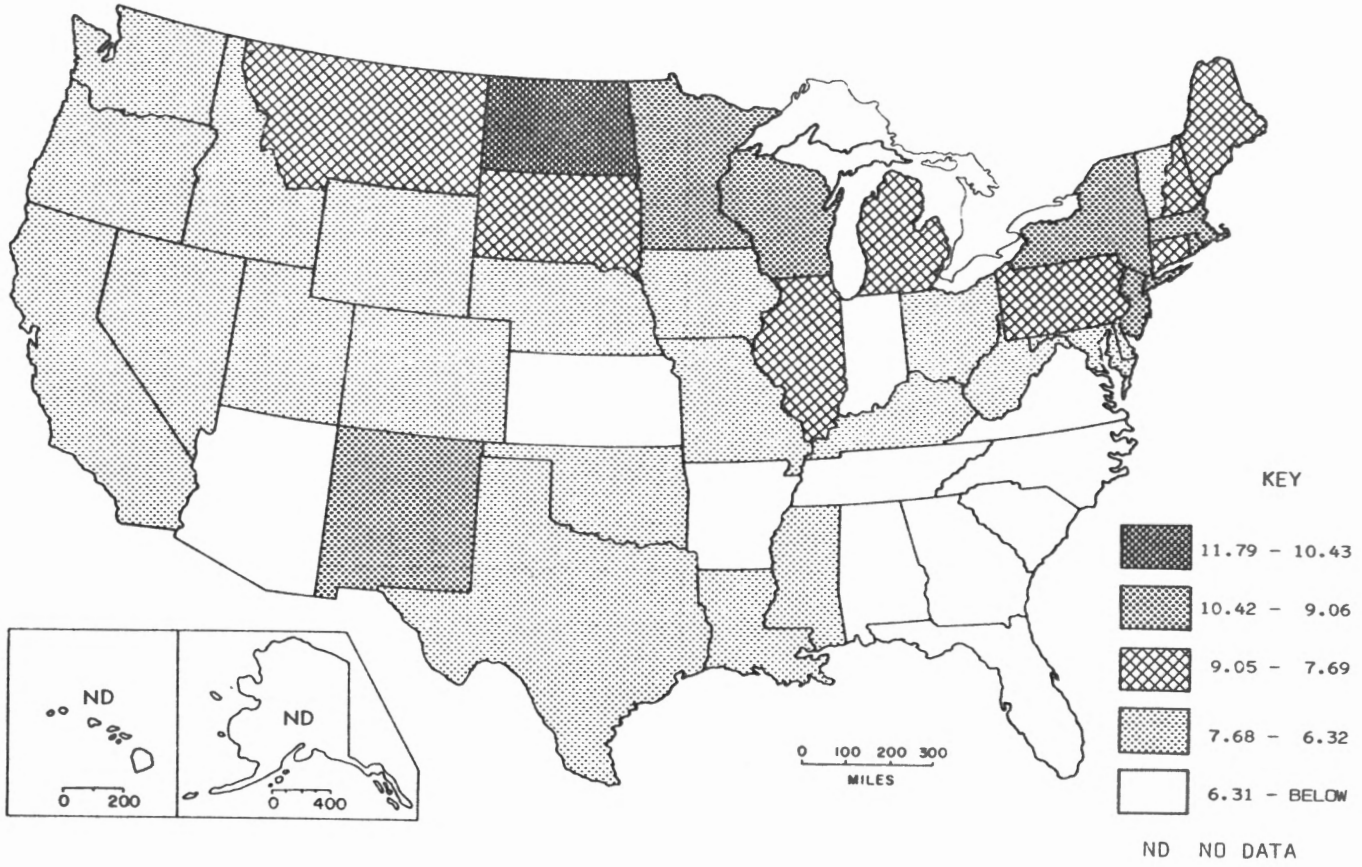



Figure 7. Stomach Cancer Death Rates Per 100,000 Nonwhite Female Population, Age-Adjusted by State: 1950-1969

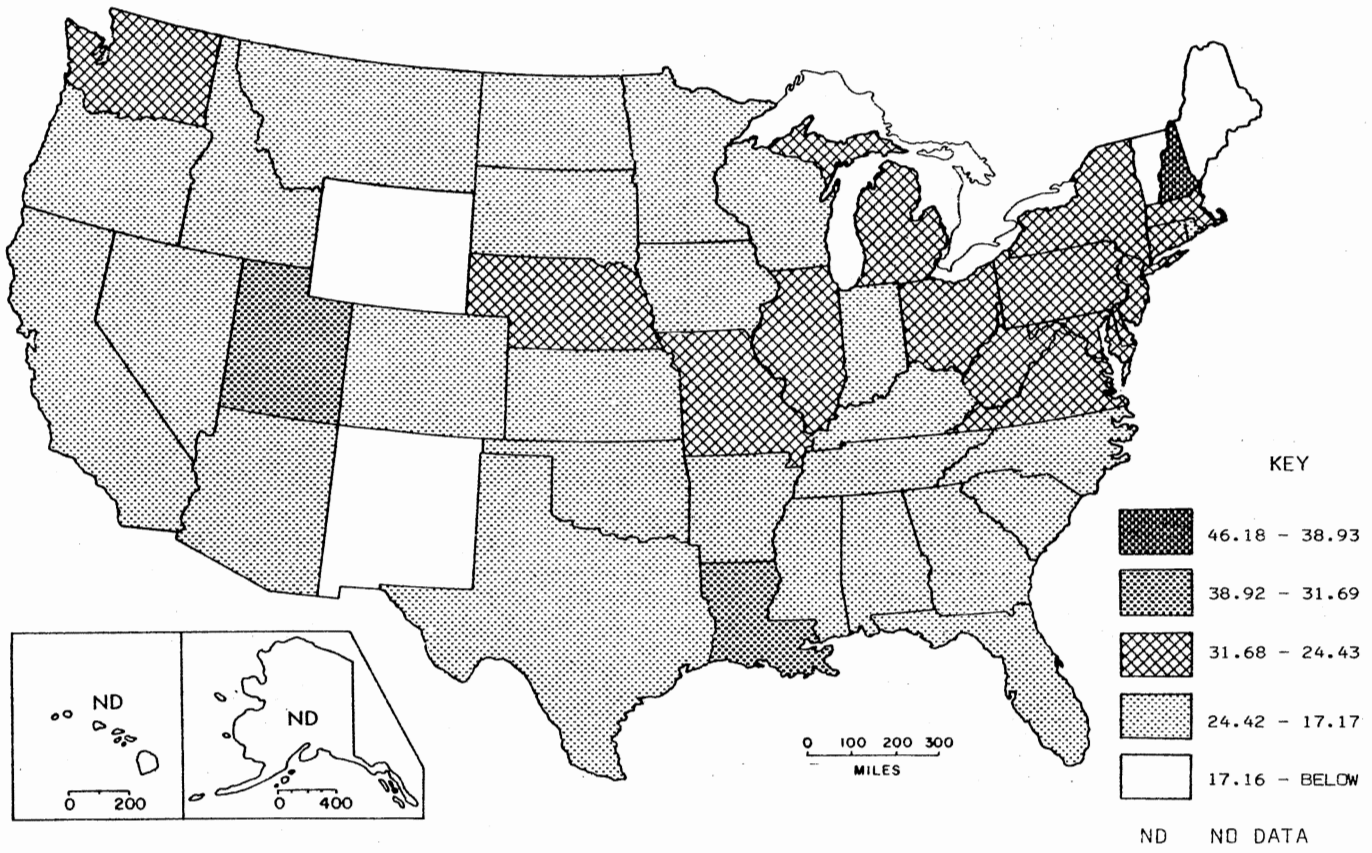



Figure 8. Stomach Cancer Death Rates Per 100,000 White Male Population, Age-Adjusted by State: 1950-1969

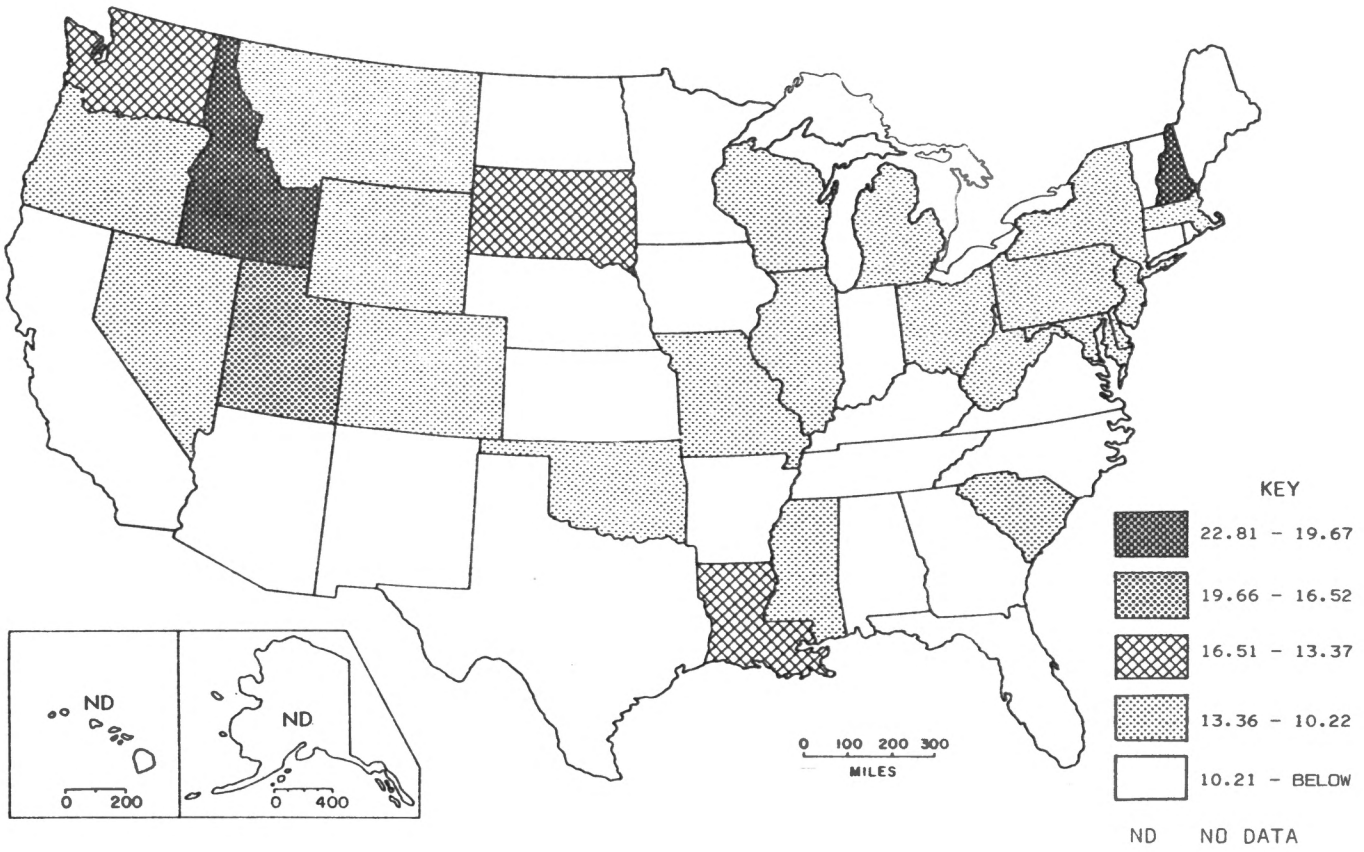



Figure 9. Stomach Cancer Death Rates Per 100,000 White Female Population, Age-Adjusted by State: 1950-1969

By looking at the maps, the mortality from stomach cancer is greater for the nonwhite than for white persons. The white male and white female maps show lower rates as compared to the nonwhite male and nonwhite female maps (Figures 6 and 7). Table IX shows the total number of stomach cancer deaths for the United States and the age-adjusted death rate for each of the nonwhite and white population. The highest death rates occur among the nonwhite population for male and female.

TABLE IX

STOMACH CANCER MORTALITY, PER 100,000:
1950 - 1969

| United States | White Male | Nonwhite Male | White Female | Nonwhite Female |
|---|---|---|---|---|
| Total Deaths | 222,524 | 33,606 | 137,254 | 16,725 |
| Age Adjusted | 15.22 | 24.03 | 7.07 | 10.69 |

Source: U.S. Cancer Mortality by County Atlas 1950-1969, U.S. Department of Health, Education, and Welfare, 1969.

The highest rates from stomach cancer has been in all nine regions for the nonwhite male population (Table X). The Middle Atlantic region has the highest death rate of 27.32 per 100,000. The differences between the white and nonwhite population groups may be based upon the regional differences in demographic characteristics and accurate reporting

TABLE X

SECTIONAL RATES PER 100,000
AGE-ADJUSTED: 1950-1969

| Geographic Divisions | White Male | Nonwhite Male | White Female | Nonwhite Female |
|---|---|---|---|---|
| Northeast | 16.02 | 23.47 | 8.51 | 11.04 |
| Middle Atlantic | 18.19 | 27.32 | 9.40 | 11.161 |
| South Atlantic | 11.40 | 24.34 | 5.97 | 10.26 |
| East North Central | 16.12 | 23.80 | 8.00 | 10.50 |
| East South Central | 11.30 | 21.24 | 9.94 | 10.36 |
| West North Central | 15.56 | 21.50 | 7.97 | 10.29 |
| West South Central | 12.37 | 22.84 | 6.52 | 10.99 |
| Mountain | 16.17 | 21.09 | 7.25 | 12.99 |
| Pacific | 14.62 | 23.94 | 7.00 | 11.09 |

of deaths for each state within the geographic region. The high death rates in the northern regions may have been enhanced by the northward migration of the Negroes from the South.[23] Also, the nonwhite population have had less access to regular medical care, and have not taken full advantage of medical facilities that are available. The differences in stomach cancer rates between the white and nonwhite population can be associated with socioeconomic status. Studies in the United States show that generally persons in the lower socioeconomic groups have above average death rates from stomach cancer.[24] It must be stressed that these are only geographic assumptions and the medical interpretation was not suggested even though the patterns will suggest possible clues to the frequency of stomach cancer in all nine geographic regions.

## 1970 - 1973

For the past several decades, stomach cancer has been occurring less and less frequently in the United States. Today only about five percent of all cancer deaths can be attributed to cancer of the stomach as compared to 20 percent during the 1930s, 1940s, and 1950s. It is estimated that about 14,300 Americans now die of stomach cancer each year.[25] Since 1950 the reporting of stomach cancer is classified as a separate cancer site by the International List of Causes of Death and a steady decline has been the trend in the United States. The geographic variation of stomach cancer during this time period will be different because of the untested new chemicals that have been introduced into various areas of the United States in the past 20 years.[26] It is now possible to partially explain intelligently some of these changes. All

areas of the country will have overall increases in stomach cancer due to exposure to carcinogens in consumer products and environmental contaminants.

Stomach cancer rates in the industrial-urbanized states of the Northeast and the North Central states continue to be on the increase (Figures 10 and 11). The North Central states, (Minnesota, Wisconsin, Upper Michigan, and the Dakotas) have experienced increases due to consumption of fish and other foods contaminated with polychlorinated biphenyls and the use of insecticides. It has been found that the death rate in Minnesota and Wisconsin, along the northern shore of Lake Superior have increased in stomach cancer rates due to the contamination of drinking water and air with asbestos.[28] Also, there has been etiological clues in Michigan concerning the rise of stomach cancer and other cancers due to the widespread contamination of livestock with polybrominated biphenyls and contaminants.

In the Northeastern state of New Jersey the high death rate of stomach cancer has always been the interest of cancer researchers. Of the 21 counties in New Jersey, eighteen have stomach cancer rates that are among the highest in the country. New Jersey is the most cancer ridden state in the country. In fact, Salem County, New Jersey has the highest death rate (16.1 per 100,000) of all American counties.[29] It should be emphasized that the geography of cancer roughly follows the geography of industries, most notably the chemical industry.[30]

Some other differences that have occurred during this time period is the increase rate in Florida as compared to the death rates during 1930 to 1950. Florida has the largest population (as of 1973) of any state in the South Atlantic region and has departed from the southern

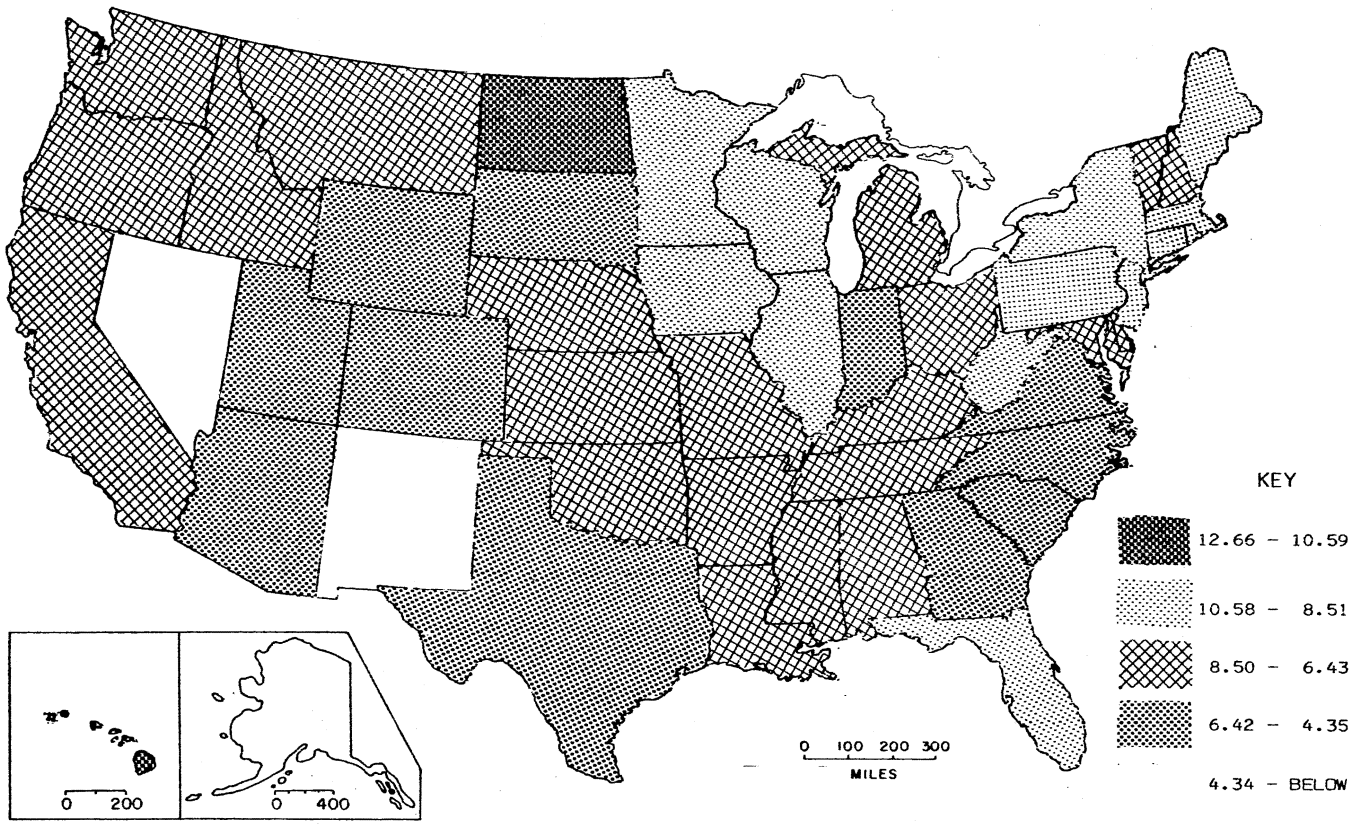



Figure 10. Stomach Cancer Death Rates Per 100,000 Population by State for 1970

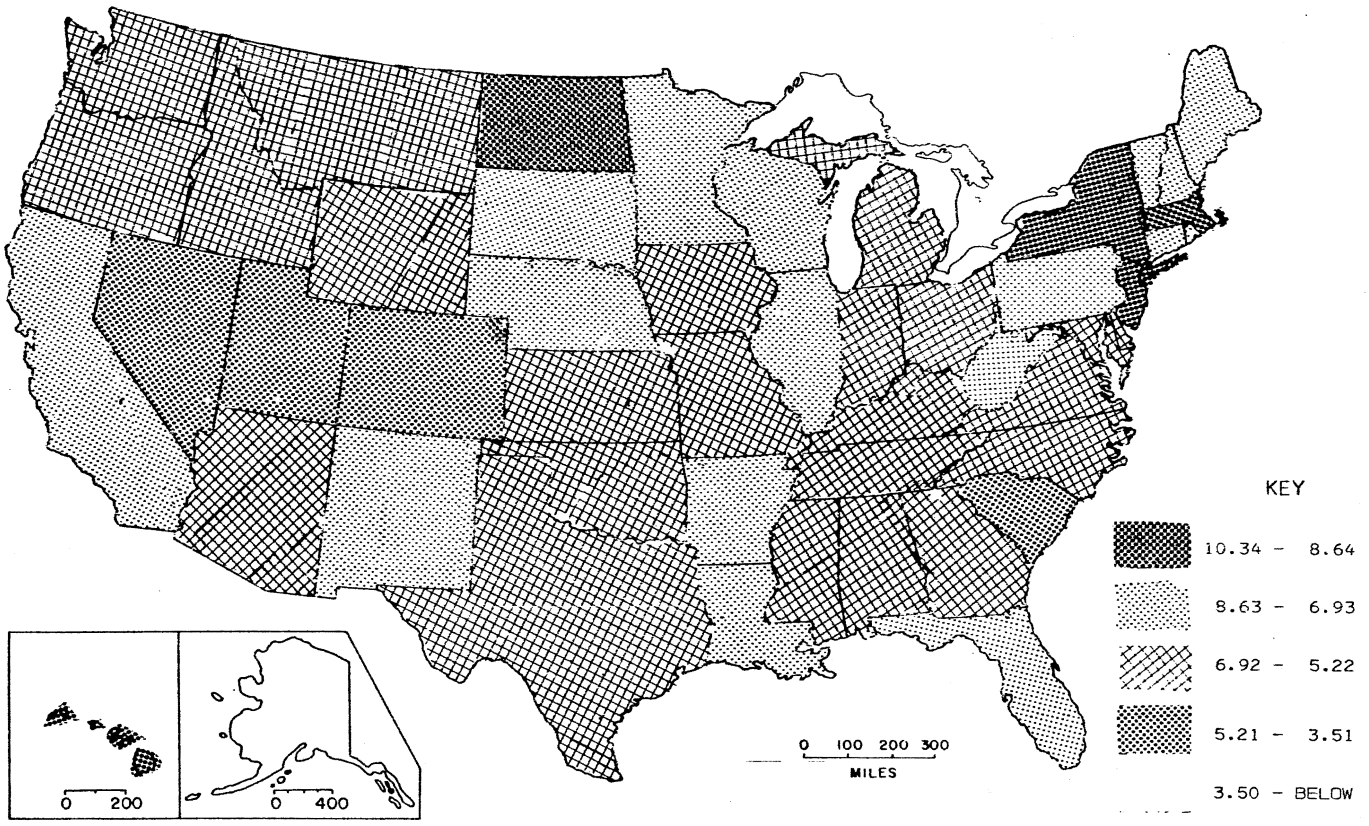


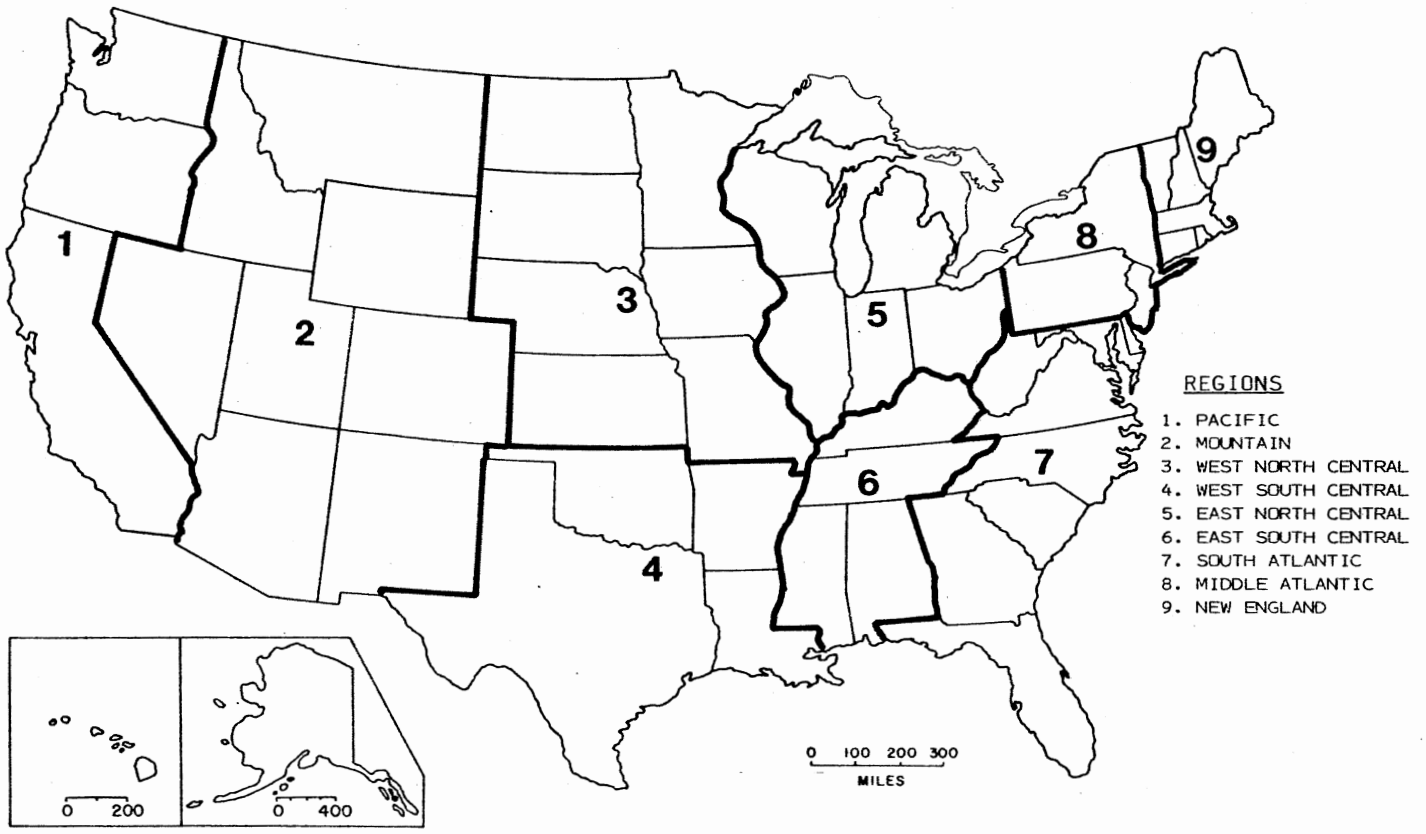

Figure 11. Stomach Cancer Death Rates Per 100,000 Population by State for 1973

pattern of low death rates. Other differences have occurred in Arkansas and Louisiana (Figure 11). The Hawaiian Islands have the highest death rate from stomach cancer for all of the 50 states and this can be attributed to the orientals, especially among the Japanese who have a high susceptibility to stomach cancer.

In general, any area with heavy industry, chemical production, and use of large quantities of insecticides can expect to increase in stomach cancer and no area is likely to escape some increases in stomach cancer due to exposure of populations to carcinogens in consumer products.

## Geographic Regions and Stomach Cancer

Since 1930 the actual death rate from stomach cancer has declined in all nine geographic regions (Figure 12). The death rates in the regions will vary according to the number of deaths and population. As it was mentioned before, the classification of stomach cancer has changed twice during this time period. From 1930 to 1950 the classification of stomach cancer was combined with duodenum (ICD 46 b, c) and beginning in 1950 the classification was reported as a separate site (ICD 151). In Table XI the death rates overall are high in the Northeast, Middle Atlantic, and East North Central, West North Central, and Pacific regions. The South Atlantic, East South Central, West South Central, and the Mountain regions have comparatively low death rates. The explanation behind these trends can be attributed to urbanization, environmental causes, and ethnic variations. The Pacific region has a high death rate and this surge in deaths has been linked to the Japanese-Americans who reside in California, Washington, and Hawaii.




Source: U.S. Bureau of the Census.

Figure 12. Geographic Regions of the United States

TABLE XI

SECTIONAL RATES PER 100,000 BY GEOGRAPHIC REGION: 1930-1973

| Geographic Region | 1930 | 1935 | 1940 | 1945 | 1950 | 1960 | 1970 | 1973 |
|---|---|---|---|---|---|---|---|---|
| Northeast | 26.08 | 27.16 | 28.46 | 25.79 | 19.50 | 15.06 | 9.66 | 8.85 |
| Middle Atlantic | 26.31 | 24.59 | 23.02 | 21.18 | 19.68 | 15.28 | 9.88 | 9.30 |
| South Atlantic | 12.95 | 13.60 | 6.81 | 13.28 | 11.37 | 8.42 | 6.17 | 4.23 |
| East North Central | 24.37 | 24.75 | 23.02 | 24.15 | 17.03 | 11.99 | 7.87 | 6.91 |
| East South Central | 12.16 | 11.41 | 12.61 | 12.66 | 10.97 | 9.59 | 7.17 | 6.35 |
| West North Central | 26.18 | 33.52 | 23.82 | 11.24 | 19.29 | 12.55 | 7.83 | 6.88 |
| West South Central | *11.50 | 12.95 | 12.82 | 15.44 | 12.34 | 9.22 | 7.00 | 6.58 |
| Mountain | 28.41 | 19.01 | 19.71 | 20.12 | 13.33 | 9.84 | 5.44 | 5.46 |
| Pacific | 27.34 | 27.30 | 25.21 | 19.67 | 15.23 | 10.80 | 7.38 | 6.98 |

*1930: Texas was not a member of the death registration area.

The Japanese have been a factor in the amount of stomach cancer among an ethnic group.[31]

The density per unit area of stomach cancer is higher in the Northern portion of the United States than in the South and this same relationship holds true for the intestine, esophagus, and rectum.[32] The regional variation for stomach cancer is not accompanied by compensatory differences for other digestive sites. Rather stomach cancer fits into the larger pattern of variation for the total digestive system.[33]

The problem with statistical reliability throughout the nine geograohic regions has been the accuracy of the data. An example of this is that the states of New York and Pennsylvania in the Middle Atlantic region portray apparently higher death rates because they will record their deaths in contrast to many areas in the South Atlantic and South Central regions where the Appalachian areas will be quite perfunctory in record keeping.[34] Another possible error which arises from the method of tabulating death rates is based on the place of death and not on the place of residence. Therefore, if patients from one state die in another state where more extensive cancer treatment facilities are available, the death rate will be higher in those states.

## Geographic Factors and Stomach Cancer

In general, the trends in the United States have shown a decline in mortality from stomach cancer (Table XII). This is a site where cancer control seems to have come about somehow by the general population's own non-deliberate actions. In search for exogenous factors that might influence the geographic distribution of stomach cancer, dietary factors are the most obvious.[35] Cancer investigators believe that diet

TABLE XII

REDUCTION IN NUMBER OF STOMACH CANCER DEATHS
IN THE UNITED STATES FROM 1936 TO 1975
BECAUSE MORTALITY RATES
DECREASED SINCE 1935

| Year | Mortality Rate Per 100,000 | Difference in Rates Since 1935 | Population (in Thousands) | Reduction in Stomach Cancer Deaths Because of Decrease In Rate Since 1935 |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) = (3) x (4) |
| 1935 | 21.3 | - | - | - |
| 6 | 21.3 | 0.0 | 128,053 | - |
| 7 | 20.9 | -0.4 | 128,825 | -515 |
| 8 | 20.9 | -0.4 | 129,825 | -519 |
| 9 | 20.0 | -1.3 | 130,880 | -1,701 |
| 1940 | 19.8 | -1.5 | 132,457 | -1,986 |
| 1 | 19.2 | -2.1 | 133,669 | -2,807 |
| 2 | 19.6 | -1.7 | 134,617 | -2,288 |
| 3 | 19.2 | -2.1 | 135,107 | -2,837 |
| 4 | 19.3 | -2.0 | 133,915 | -2,678 |
| 5 | 19.5 | -1.8 | 133,434 | -2,401 |
| 6 | 18.3 | -3.0 | 140,686 | -4,220 |
| 7 | 18.1 | -3.2 | 144,083 | -4,610 |
| 8 | 17.9 | -3.4 | 146,730 | -4,988 |
| 9 | 16.7 | -4.6 | 149,304 | -6,867 |
| 1950 | 16.1 | -5.2 | 151,868 | -7,897 |
| 1 | 15.4 | -5.9 | 153,982 | -9,084 |
| 2 | 15.1 | -6.2 | 156,393 | -9,696 |
| 3 | 14.8 | -6.5 | 158,956 | -10,332 |
| 4 | 14.3 | -7.0 | 161,884 | -11,331 |
| 5 | 13.5 | -7.8 | 165,069 | -12,875 |
| 6 | 13.2 | -8.1 | 168,088 | -13,615 |
| 7 | 12.6 | -8.7 | 171,187 | -14,893 |
| 8 | 12.1 | -9.2 | 174,149 | -16,021 |
| 9 | 11.9 | -9.4 | 177,135 | -16,650 |
| 1960 | 11.6 | -9.7 | 179,979 | -17,547 |
| 1 | 11.0 | -10.3 | 182,992 | -18,848 |
| 2 | 10.4 | -10.9 | 185,771 | -20,249 |
| 3 | 10.2 | -11.1 | 188,483 | -20,921 |
| 4 | 9.7 | -11.6 | 191,141 | -22,172 |
| 5 | 9.3 | -12.0 | 193,526 | -23,223 |
| 6 | 9.0 | -12.3 | 195,576 | -24,055 |
| 7 | 8.6 | -12.7 | 197,457 | -25,077 |
| 8 | 8.5 | -12.8 | 199,399 | -25,523 |
| 9 | 8.1 | -13.2 | 201,385 | -26,582 |

TABLE XII (Continued)

| Year | Mortality Rate Per 100,000 | Difference in Rates Since 1935 | Population (in Thousands) | Reduction in Stomach Cancer Deaths Because of Decrease In Rate Since 1935 |
|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) = (3) x (4) |
| 1970 | 7.9 | -13.4 | 203,810 | -27,210 |
| 1 | 7.4 | -13.8 | 206,219 | -28,458 |
| 2 | 7.1x | -13.9 | 208,234 | -28,944 |
| 3 | 6.8x | -14.2 | 209,860 | -29,800 |
| 4 | 6.8x | -14.5 | 211,389 | -30,651 |
| 5 | 6.6x | -14.7 | 212,965+ | -21,305 |
| | | | TOTAL 1936 - 1975 | -561,386 |

x Estimates based on 1966-72 rates
\+ June 1975

1935-38 ICD (Fourth Revision) Includes duodenum.
1939-48 ICD (Fifth Revision) #46 b
1949-67 ICD (Seventh Revision) #151
1968- ICD (Eighth Revision) #151

U.S. Rates in the U.S. 1940-1960
Annual Vital Statistics of the United States 1960-1972
Population: Statistical Abstract of the U.S. 1975, p. 5

Source: A History of Cancer Control in the United States 1946-1975, DHEW Publication No. (NIH) 79-1516.

must be at least partially responsible for the downward trend in incidence of stomach cancer in the United States. In the past 60 years great changes in food habits are known to have taken place especially during the first half of the century.[36] The possible dietary effects will fall into three categories:[37]

1. Presence of a carcinogen occurring naturally in food, including such physical properties as food texture.
2. Carcinogen introduced in food preparation, including such physical properties as food temperature.
3. The absence of some protective factor. Since the stomach is considered to be a nonexcretionary organ, the direct action of a carcinogenic agent must be considered as a plausible hypothesis.

Detection of association between commonly used foods and stomach cancer is difficult to study in populations where today nearly everyone adheres to the same basic diet. This holds true in the United States because of the improved nutritional habits that have occurred among the population. Some of the more striking features for the United States include the trend to greatly increased use of citrus fruits and lettuce, the latter having displaced cabbage as the major green leafy vegetable. The decline in the consumption of potatoes and wheat flour; the larger amounts of beef, milk, citrus fruits, and green vegetables in high income diets. Oranges have displaced apples during the period of declining stomach cancer rates.[38] The major discrepancy is relating the use of lettuce and cabbage to the southern states.[39] This configuration will warrant further investigation concerning the relation of citrus fruits and lettuce to stomach cancer.

The nutritional habits of countries in the world are different and stomach cancer is related to diet. Stomach cancer is extremely high in Eastern Europe, Japan, Finland, Norway, Sweden, Iceland, and South America. These countries and their foodways are different from those of the United States. The best way to study dietary factors when pertinent data are available to observe dietary changes that have taken place with time and to study the changing foodways among a migrant population such as from Europe and Japan to the United States.

The most frequently used study to compare the incidence of stomach cancer and diet is comparing Japan and the United States.[40] In the United States the consumption of dairy products, meat, poultry, fats, oils, fruit, and sugar is higher in nutritional value than the Japanese diet of rice, fish, bean products, and sweet potatoes. The differences in these diets resembles a higher rate of stomach cancer in the Japanese. The Japanese migrants to the United States and their United States born descendants have a decreased stomach cancer rate, which is, however, higher than that of the United States white population.[41]

The higher latitude countries of Norway, Sweden, Finland, and Iceland have a high rate of stomach cancer. The basic economic activity for these countries is the fishing industry and fish are part of their daily diet. Fish has been a major food group for developing stomach cancer. The processing of fish will have a chemical known as nitrasamines which are potent carcinogens resulting from interaction of nitrate and nitrites. In the United States, fish is part of the American diet but changes in processing have occurred to help eliminate some of the carcinogens. During the heavy migration of the Scandinavians to Minnesota and Wisconsin, the death rate from stomach cancer was high and this

may have been attributed to the consumption of fish. Also the effect of latitude will determine the type of crops which can be grown. The lack of citrus fruits and vegetables in these countries have been linked to stomach cancer and appears to be prevalent among several populations with high stomach cancer rates.

Since dietary habits are influenced by socioeconomic factors, which in turn is known to be related to stomach cancer, it is apparent that economic factors affect the types of food consumed. Stomach cancer seems to occur most frequently among low income persons than among those higher upon the socioeconomic scale.

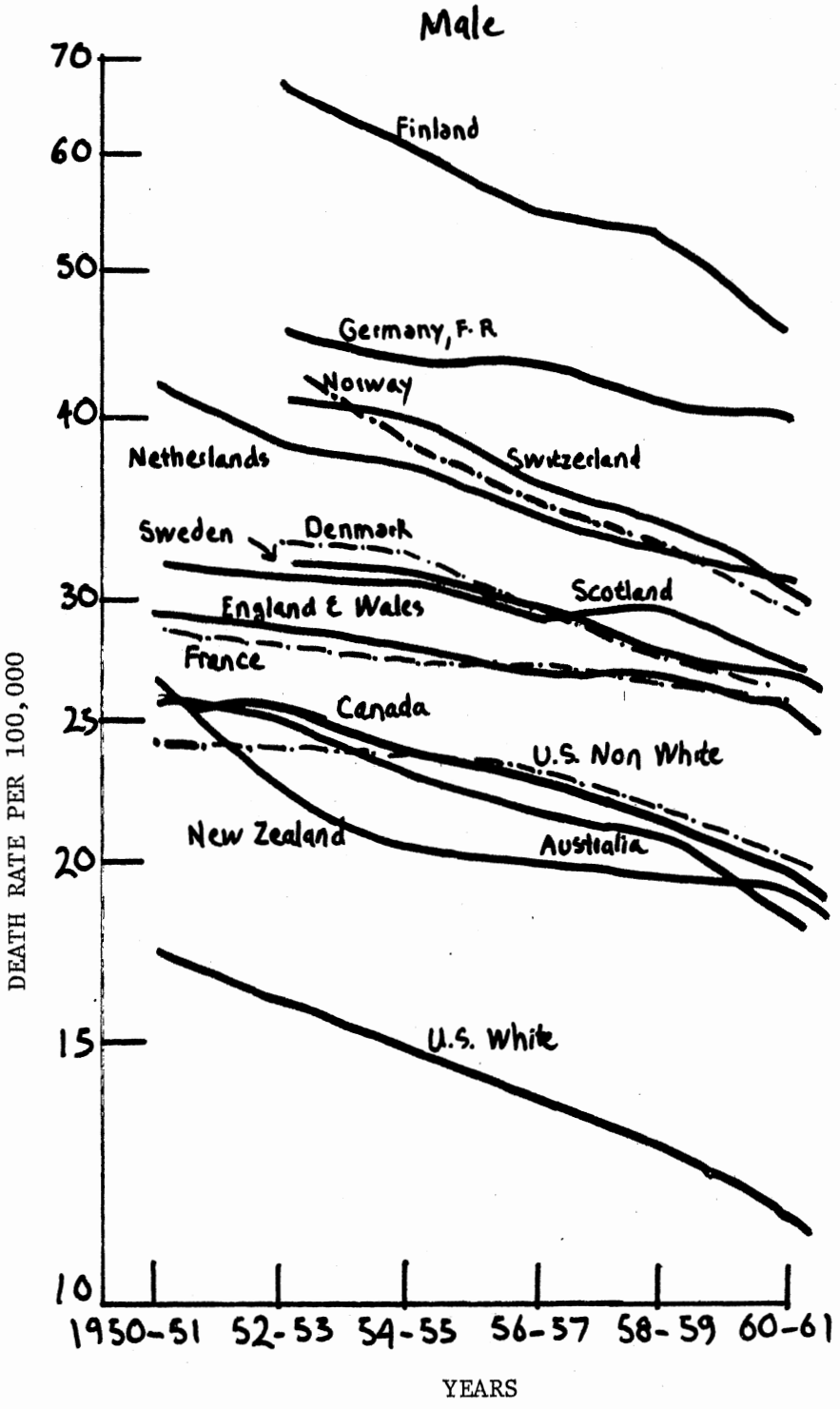
These comments on the effects of diet involved selection and interpretation of recorded facts and must be regarded as in the realm of speculation. They are mentioned as illustrations of how diet may affect the geographical distribution of stomach cancer throughout the world. Further investigation is need to fully understand whether an excess of dietary factors, dietary deficiency, or the combination of the two will contribute to the global incidence of stomach cancer. It has been suggested by cancer researchers that the collection of dietary histories among a population is imperative for accurate etiological investigation. Because of the long latent period between exposure and development of stomach cancer, the dietary histories of stomach cancer patients and families will have to cover long periods of time. Under these considerations the results will have to cover long periods of time. Under these considerations the results from studies may prove misleading.

Although it has been suggested that excessive consumption of alcoholic beverages, habitual drinking of very hot or very cold liquids,

chewing tobacco, rapidity of eating, and the temperature of food may cause stomach cancer, there is no scientific proof that any of these factors are involved.[42] There have been possible association with stomach cancer to air pollution, highly seasoned food, soils, and industrial chemicals. Also, it has long been suggested that stomach cancer runs in families and several studies done by the National Cancer Institute have shown that close relatives of stomach cancer patients are two or three times as likely to develop the disease as are persons in the general population.[43] This increased risk may be due more to a shared environment than to any inherited susceptibility.

## International Distribution of Stomach Cancer

Mortality rates for stomach cancer have been decreasing in the United States and also a decline has been seen in several other countries. Japan which has one of the highest rates in the world shows no evidence of a decline among the males and only a suggestion of one among females. Iceland has a high death rate from stomach cancer and this can be attributed to the methods of preparing or preserving food. The high rate of stomach cancer in Iceland supports evidence of a relationship to the consumption of home smoked singed foods.[44] This occurrence of high death rates in Finland, Norway, and Sweden may relate to the preparation and preserving of food as in Iceland. The decline of stomach cancer in males is seen in Figure 13. One of the most dramatic aspects of this decline is seen for the United States white population and also a reduction of deaths for the Western European countries. In every country, stomach cancer will occur more frequently in men than in women.[45] Migrant studies strongly indicate the role of




Source: M. Segi, et al., Cancer Mortality for Selected Countries.

Figure 13. Stomach Cancer Mortality Per 100,000 Male Population for the Western Countries: 1950-1961

dietary and environmental factors as a reason for this decline. For all countries there is a trend of decreasing mortality throughout the 12 year period.

The international variations of stomach cancer mortality is spatially distributed throughout the world. Table XIII summarizes the countries having high death rates from stomach cancer. Notice that the majority of the countries reporting high death rates are in the northern latitudes from 40° North to 66½° North with the only exception of Chile and New Zealand. These two southern hemisphere countries are approximately in the same latitudinal location. Differences in stomach cancer mortality among migrants to the United States from high risk populations generally tend to have lower death rates than their native country of origin.[46] It can be inferred that the earlier the age of migration, the lesser chance of having stomach cancer.[47] Table XV shows the migrants who are susceptible of having stomach cancer.

From the previous two tables, numerous factors complicate the actual interpretation of the findings on migrant populations. These include variations in medical care, accurate diagnosis of death certificates, selection of migrants in good or poor health, and differences in socioeconomic class distribution.[48] The possibility remains that there are specific relationships between country of birth and stomach cancer which are produced for other cancer sites.[49] If something like this is true, further research can profitably examine the prevailing customs among the foreign born for leads on possible cultural characteristics as well as environmental agents in the etiology of stomach cancer. The geographic distribution of cancer in general and the migrant is best stated by P. E. Steiner:[50]

TABLE XIII

INTERNATIONAL COMPARISONS OF
STOMACH CANCER MORTALITY

| |
|---|
| EXTREMELY HIGH |
| Japan |
| New Zealand |
| Israel |
| VERY HIGH |
| Chile |
| Finland |
| England-Wales |
| Scotland |
| Portugal |
| HIGH |
| Austria |
| Germany |
| Italy |
| Norway |
| MODERATELY HIGH |
| Canada |
| Denmark |
| Ireland |
| Sweden |

Source: David L. Levin, et al., Cancer Rates and Risks, (2nd ed., 1974), pp. 28-29.

TABLE XIV

STOMACH CANCER MORTALITY OF MIGRANTS
TO THE UNITED STATES

| Stomach Cancer: Large Excess Risk Among Migrants |
|---|
| Austria |
| Czechoslovakia |
| Finland |
| Germany |
| Ireland |
| Japan |
| Mexico |
| Norway |
| Poland |
| Sweden |
| U.S.S.R. |
| Yugoslavia |

Source: David L. Levin, et al., Cancer Rates and Risks (2nd ed., 1974), p. 30.

> It is possible, of course to perform planned experiments on the etiology of cancer in man. Members of certain races have, however, unwittingly performed etiological experiments on a larger scale by migration from one environment to another. The genertic characteristics of such a population may at first remain relatively unchanged, but the new environment may be different from the old in some respects. Factors such as climate, latitude, air pollution, temperature, humidity, and the amount of solar radiation and intercurrent disease may differ at once. These factors may affect the migrant both directly and indirectly through their skin, air, food, water supply, and possibly other ways. On the other hand certain environmental factors, some of which may be cultural change more slowly after migration. The choice of food and culinary practices, occupational exposures, sanitary habits, economic level, and other factors will generally change over a period of years . . .[50]

## Summary

It has been found that stomach cancer is geographic throughout the world and the key findings from this chapter are as follows:

1. There are great variations among countries in stomach cancer rates.
2. The Northwestern, North Central, and Pacific regions will have higher death rates from stomach cancer than the rest of the country.
3. In the United States, the risk of developing stomach cancer seems to be greater for nonwhite than for white persons.
4. Migrants will be an important factor in determining a stomach cancer mortality in the United States.
5. The geographic distribution of stomach cancer throughout the world suggests that dietary factors will influence the incidence of stomach cancer.

6. The accuracy of mortality statistics will vary from state to state and from country to country.
7. Age-adjusted death rates will geographically vary from state to state according to age, sex, and race of the population.

FOOTNOTES

[1]World Health Organization, Mortality from Malignant Neoplasms, 1955-1965, Vol. 1-2, 1970.

[2]Joyce Haley, "Stomach Cancer Mortality: A Comparison of Age-Specific Death Rates in Different Countries," Racial and Geographical Factors in Tumour Incidence, Medical Monograph 2 (1967), p. 69.

[3]Malcolm A. Murray, "The Geography of Death in the United States and United Kingdom," Annals, Association of American Geographers, Vol. 57 (1967), p. 301.

[4]Ibid., p. 311.

[5]Harold F. Dorn, "Cancer Mortality Trends in the United States of America," Cancer, Vol. 3 (1958), p. 209.

[6]Ibid.

[7]Gerald F. Pyle, Heart Disease, Cancer, and Stroke in Chicago, The University of Chicago, Department of Geography Research Paper 134 (Chicago, 1971), p. 46.

[8]Harold F. Dorn, "Cancer Mortality Trends in the United States of America," Cancer, Vol. 3 (1958), p. 227.

[9]Ibid.

[10]William Haenzel, "Cancer Mortality Among the Foreign Born in the United States," Journal of National Cancer Institute, Vol. 26 (1961), pp. 37-132.

[11]Duodenum: the part of the small intestine below the stomach.

[12]The categories for each map during this time period will change in intervals. It is not feasible to use the same mapping categories since deaths per 100,000 population will cahnge according to population and total deaths that have occurred from stomach and duodenum cancer.

[13]Gerald F. Pyle, Heart Disease, Cancer, and Stroke in Chicago, The University of Chicago, Department of Geography Research Paper 134 (Chicago, 1971), p. 47.

[14]A Statistical Abstract Supplement, County and City Data Book, 1952, (Washington 1953).

[15]T. J. Mason and F. W. McKay, U.S. Cancer Mortality by County, 1950-1969, Department of Health, Education, and Welfare Publication Number (NIH) 74-615 (Washington, 1973).

[16]Age-adjusted: Age is adjusted to the standard population for a specified time period, This yields expected deaths which are summed to a total for all ages.

[17]David L. Levin et al., Cancer Rates and Risks (2nd ed., Washington, 1974), p. 17.

[18]Ibid., p. 18.

[19]What Black Americans Should Know About Cancer, U.S. Department of Health, Education, and Welfare, National Institute of Health (December, 1978), p. 4.

[20]William Haenzel, "Variation in Incidence of and Mortality from Stomach Cancer, with Particular Reference to the United States," Journal of the National Cancer Institute, Vol. 21 (1958), pp. 213-262.

[21]William Haenzel, et al., "Stomach Cancer Among the Japanese in Hawaii," Journal of the National Cancer Institute, Vol. 49 (1972), pp. 969-998.

[22]William Haenzel, "Variation in Incidence of and Mortality from Stomach Cancer, with Particular Reference to the United States," Journal of the National Cancer Institute, Vol. 21 (1958), p. 234.

[23]Ibid.

[24]Progress Against Cancer of the Stomach, U.S. Department of Health, Education, and Welfare, National Institute of Health (1974).

[25]Ibid.

[26]Thomas H. Corbett, Cancer and Chemicals, Nelson and Hall, Chicago, p. 101.

[27]Ibid.

[28]Ibid.

[29]Ibid., p. 99.

[30]"Geography of Cancer: Outbreak in Rutherford, New Jersey," Time, Vol. 111 (April 24, 1978), p. 64.

[31]William Haenzel, et al., "Stomach Cancer Among the Japanese in Hawaii," Journal of the National Cancer Institute, Vol. 49 (1972), pp. 969-998.

[32]William Haenzel, "Variation in Incidence of and Mortality from Stomach Cancer, with Particular Reference to the United States," Journal of the National Cancer Institute, Vol. 21 (1958), p. 231.

[33]Ibid.

[34]Malcolm A. Murray, "The Geography of Death in the United States and United Kingdom," Annals, Association of American Geographers, Vol. 57 (1967), p. 311.

[35]William Haenzel, "Variation in Incidence of and Mortality from Stomach Cancer, with Particular Reference to the United States," Journal of the National Cancer Institute, Vol. 21 (1958), p. 231.

[36]Ibid., p. 230.

[37]Ibid., p. 251.

[38]Progress Against Cancer of the Stomach. U.S. Department of Health, Education, and Welfare, National Institute of Health (1974).

[39]William Haenzel, "Variation in Incidence of and Mortality from Stomach Cancer, with Particular Reference to the United States," Journal of the National Cancer Institute, Vol. 21 (1958), p. 253.

[40]Joyce Haley, "Stomach Cancer Mortality: A Comparison of Age-Specific Death Rates in Different Countries," Racial and Geographical Factors in Tumour Incidence, Medical Monograph 2 (1967), p. 69.

[41]Progress Against Cancer of the Stomach, U.S. Department of Health, Education, and Welfare, National Institute of Health (1974).

[42]E. L. Wynder, et al., "An Epidemiological Investigation of Gastric Cancer," Cancer, Vol. 16 (1963), pp. 1461-69.

[43]Progress Against Cancer of the Stomach, U.S. Department of Health, Education, and Welfare, National Institute of Health (1974).

[44]Niels Dungal, "Cancer in Iceland," Cancer, Vol. 3 (1958), p. 262.

[45]Progress Against Cancer of the Stomach, U.S. Department of Health, Education, and Welfare, National Institute of Health (1974).

[46]E. L. Wynder, "On the Epidemiology of Gastric Cancer," Racial and Geographical Factors in Tumour Incidence, Medical Monograph 7 (1967), p. 55.

[47]Ibid., p. 55.

[48]David L. Levin et al., Cancer Rates and Risks (2nd ed., Washington, 1974), p. 29.

[49]William Haenzel, "Variation in Incidence of and Mortality from Stomach Cancer, with Particular Reference to the United States," Journal of the National Cancer Institute, Vol. 21 (1958), p. 247,

[50]P. E. Steiner, Race and Geography (Baltimore, 1954), pp. 363.

# CHAPTER IV

# ANALYSIS

## Introduction

"Well founded statistical correlations are "facts," and should therefore be placed on record and not disregarded because no reason for them can be perceived."[1]

It has been said that statistics cannot prove causation and therefore cancer statistics will never solve the problems of aetiology of that disease.[2] The first part of this statement has lost much of its meaning because today there is a probable causation linked between stomach cancer and explanatory variables in our society. This change has occurred because the scientific approach to the geography of cancer is multiple.[3] There are two components that will explain the spatial pattern of stomach cancer: spatial component and the statistical component. The spatial component was demonstrated in the previous chapter showing the spatial pattern of stomach cancer through maps. The statistical component will consist of finding explanatory variables that will explain the geography of stomach cancer.

This chapter will look at the relationship of stomach cancer to selected demographic, socioeconomic, and occupational variables. The best technique used for testing the statistical relationship is correlation. This will measure the strength of the association between the

dependent variable stomach cancer to the independent variables. The analysis will examine the years from 1940 to 1973. It must be pointed out that different independent variables will be entered for certain years due to the changes that occurred in the County and City Data Book. The unit of observations will be the United States, for the study period 1940 and 1950, 48 states are used and 50 states are used in 1960, 1970, and 1973.

## Selection of Independent Variables

The independent variables were chosen due to their predicted relationship to stomach cancer. The demographic, occupational, and socioeconomic variables are found in Table XV. The demographic variables are constant throughout the analysis. Population per square mile (PPSQMI) was selected because it was assumed that density would be important in explaining the pattern of stomach cancer. Percent urban (PERURB) would explain if urbanization is a factor since a higher risk would be associated with the urban population. The variables percent foreign stock (FORSTOC), percent nonwhite (PERNONWH), and percent Negro (PERNEG) would be surrogates for ethnicity. Ethnicity is an important variable used to disclose aetiological factors of stomach cancer. The age factor was taken into consideration since the risk of having stomach cancer increases with age. The variables median age (MEDAGE), SIXTYFIV, and EIGHTEEN would omit the very young and the very old and this will increase the error in accurately predicting the relationship to stomach cancer.

The occupational variables percent agriculture (PERAG) and percent manufacturing (PERMANF) were chosen because statistical studies

TABLE XV

INDEPENDENT VARIABLES

| Symbol | |
|---|---|
| **1940** | |
| PPSQMI | Population Per Square Mile |
| PERURB | Percent Urban |
| PERWHITE | Percent White |
| PERAG | Percent Agriculture |
| **1950** | |
| PPSQMI | Population Per Square Mile |
| PERURB | Percent Urban |
| PERNONWH | Percent Nonwhite |
| SIXTYFIV+ | Sixty-five Years and Older |
| MEDAGE | Median Age |
| PERMANF | Percent Manufacturing |
| PERAG | Percent Agriculture |
| **1960** | |
| PPSQMI | Population Per Square Mile |
| PERURB | Percent Urban |
| PERNEG | Percent Negro |
| FORSTOC | Foreign Stock |
| SIXTYFIV+ | Sixty-five Years and Older |
| **1970 and 1973** | |
| PPSQMI | Population Per Square Mile |
| PERURB | Percent Urban |
| PERFEM | Percent Female |
| EIGHTEEN+ | Eighteen Years and Older |
| SIXTYFIV+ | Sixty-Five Years and Older |
| MEDAGE | Median Age |
| FORSTOC | Foreign Stock |
| INC1 | Less than $3,000 |
| INC2 | $3,000-4,699 |
| INC3 | $5,000-6,999 |
| INC4 | $10,000-14,999 |
| INC5 | $15,000-24,999 |
| INC6 | $25,000 - ++ |
| PERMANF | Percent Manufacture |

Source: U.S. Dept. of Commerce, Bureau of the Census, County and City Data Book.

been important in establishing the existence of occupational hazards among workers who may come into contact with potential cancer producing agents. Finally, studies in cancer have linked socioeconomic status to stomach cancer especially to certain levels of income. The levels of income will be tested only for 1970 and 1973. The outcome of these variables will not prove causation only statistical relationship to stomach cancer.

## Results of the Analysis

To begin the analysis on stomach cancer, Table XVI provides descriptive statistics for each of the study years. The general trend as shown by the means shows a steady decline of deaths per 100,000 population from stomach cancer for the United States. The maximum and minimum values show a considerable spread, but the range is not particularly helpful as a summary of geographic variation.[4] The standard deviations show that the degree of variation during the study period is in the same order as the means. The coefficient of variation shows that stomach cancer has a greater variation about the mean in 1940. The coefficient of variation is the ratio of the standard deviation to the mean:

$$V = \frac{\sigma}{\overline{X}}$$

where $\sigma$ represents the standard deviation and $\overline{X}$ represents the mean. The higher the coefficient, the greater is the variation.

## Results for 1940

The variable PERWHITE was the most important variable explaining

TABLE XVI

DESCRIPTIVE STATISTICS FOR STOMACH CANCER
IN THE UNITED STATES
1940 - 1973

| Characteristic | Deaths Per 100,000 | | | | |
|---|---|---|---|---|---|
| | 1940 | 1950 | 1960 | 1970 | 1973 |
| Mean | 20.07 | 15.63 | 11.16 | 7.43 | 6.82 |
| Maximum | 29.83 | 22.01 | 16.43 | 12.66 | 10.34 |
| Minimum | 5.95 | 2.00 | 3.53 | 2.30 | 1.81 |
| Range | 23.88 | 20.01 | 12.90 | 10.36 | 8.53 |
| Standard Deviation | 6.27 | 3.77 | 3.06 | 2.04 | 1.59 |
| Coefficient of Variation | .31 | .24 | .27 | .27 | .23 |

TABLE XVII

A CORRELATION MATRIX FOR THE INDEPENDENT
VARIABLES: 1940

| | STOMACH CANCER | PPSQMI | PERURB | PERWHITE | PERAG |
|---|---|---|---|---|---|
| STOMACH CANCER | 1.00 | | | | |
| PPSQMI | .23 | | | | |
| PERURB | *.51 | *.74 | | | |
| PERWHITE | *.77 | .14 | *.42 | | |
| PERAG | *-.48 | *.58 | *.84 | *-.42 | |

*.01 set as the research significance level.

stomach cancer in the United States. According to the correlation coefficients in Table XVII, the demographic variables, PERURB and PERWHITE have the strongest correlation to stomach cancer. PERURB explains 24.3 percent of the variance and PERWHITE explains 60.3 percent of the variance. There is a positive correlation among the variables PPSQMI to PERURB and PERWHITE. The occupational variable PERAG indicates that individuals who are in agricultural pursuits (nearly all of whom live in rural areas) have comparatively low chances of having stomach cancer.

## Results for 1950

The correlation coefficients show that stomach cancer is positively correlated to PPSQMI, PERURB, MEDAGE, PERMANF, and SIXTYFIV (Table XVIII). The age variables are the most important variables explaining stomach cancer for 1950. SIXTYFIV explains 51.8 percent of the variance and MEDAGE explains 49.8 percent of the variance. The other variables that show a negative correlation are PERNONWH and PERAG. The variable PERAG is negatively correlated to stomach cancer and many aspects of the rural areas and the urban areas are different and it would be difficult to distinguish the separate affects concerning the difference.

## Results for 1960

According to the correlation matrix in Table XIX, the ethnic variable FORSTOC has the strongest correlation to stomach cancer. Even though the correlation is negative, it does show that people of foreign stock are likely not to have stomach cancer. The other reason behind this correlation may reflect the foreign stock dominance for a state which may have a higher percentage of a certain group as reported by the

TABLE XVIII

A CORRELATION MATRIX FOR THE INDEPENDENT VARIABLES: 1950

| | STOMACH CANCER | PPSQMI | PERURB | PERNONWH | SIXTYFIV | MEDAGE | PERMANF | PERAG |
|---|---|---|---|---|---|---|---|---|
| STOMACH CANCER | 1.00 | | | | | | | |
| PPSQMI | *.34 | | | | | | | |
| PERURB | *.39 | *.66 | | | | | | |
| PERNONWH | *-.62 | -.11 | -.33 | | | | | |
| SIXTYFIV | *.72 | .19 | .27 | *-.57 | | | | |
| MEDAGE | *.70 | *.41 | *.75 | *-.60 | *.71 | | | |
| PERMANF | .30 | *.67 | *.56 | -.05 | .32 | *.40 | | |
| PERAG | -.22 | *-.85 | *-.85 | .31 | -.18 | *-.57 | *-.65 | |

*.01 set as the research significance level.

Census Bureau and not a true representation of a state. The demographic variables PPSQMI, PERURB, and the age variable SIXTYFIV have a positive correlation to stomach cancer.

TABLE XIX

A CORRELATION MATRIX FOR THE INDEPENDENT VARIABLES: 1960

| | STOMACH CANCER | PPSQMI | PERURB | PERNEG | FORSTOC | SIXTYFIV |
|---|---|---|---|---|---|---|
| STOMACH CANCER | 1.00 | | | | | |
| PPSQMI | *.37 | | | | | |
| PERURB | *.36 | *.59 | | | | |
| PERNEG | *-.34 | -.03 | -.20 | | | |
| FORSTOC | *-.45 | *-.38 | -.03 | -.14 | | |
| SIXTYFIV | *.29 | -.20 | -.11 | -.11 | -.17 | |

*.01 set as the research significance level.

Results for 1970 and 1973

In Table XX and Table XXI the correlation coefficients are shown. According to the coefficients, the most important variable in explaining stomach cancer in the United States during this time is the demographic variable PPSQMI. Density is a factor in explaining stomach

TABLE XX

A CORRELATION MATRIX FOR THE INDEPENDENT VARIABLES: 1970

| | STOMACH CANCER | PPSQMI | PERURB | PERFEM | EIGHTEEN | SIXTYFIV | MEDAGE | FORSTOC | INC1 | INC2 | INC3 | INC4 | INC5 | INC6 | PERMANF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STOMACH CANCER | 1.00 | | | | | | | | | | | | | | |
| PPSQMI | *.42 | | | | | | | | | | | | | | |
| PERURB | .16 | *.50 | | | | | | | | | | | | | |
| PERFEM | .27 | .30 | .14 | | | | | | | | | | | | |
| EIGHTEEN | *.35 | *.145 | .25 | *.46 | | | | | | | | | | | |
| SIXTYFIV | *.37 | .08 | -.12 | *.66 | *.57 | | | | | | | | | | |
| MEDAGE | *.38 | *.39 | .21 | *.56 | *.85 | *.75 | | | | | | | | | |
| FORSTOC | .24 | -.13 | -.17 | .01 | -.14 | .12 | -.06 | | | | | | | | |
| INC1 | -.06 | *-.38 | *-.53 | .23 | -.19 | .20 | -.13 | .00 | | | | | | | |
| INC2 | -.08 | *-.48 | *-.57 | .21 | -.15 | *.37 | -.01 | .07 | *.90 | | | | | | |
| INC3 | .07 | *.52 | *-.68 | .09 | -.17 | .31 | -.08 | .23 | *.74 | *.89 | | | | | |
| INC4 | .06 | *.45 | *.58 | .00 | .24 | -.12 | -.17 | -.07 | *-.92 | *-.92 | *.84 | | | | |
| INC5 | .09 | *.44 | *.62 | *-.37 | .08 | *.47 | -.02 | -.14 | *-.79 | *-.89 | *-.91 | *.74 | | | |
| INC6 | .10 | *.45 | *.59 | *-.38 | .09 | *-.44 | .00 | -.09 | *-.68 | *-.76 | *-.80 | *.57 | *.94 | | |
| PERMANF | .03 | *.36 | .16 | *.38 | *.36 | .00 | .28 | -.07 | -.15 | -.28 | -.32 | *.36 | .13 | .00 | |

*.01 set as the research significance level.

TABLE XXI

A CORRELATION MATRIX FOR THE INDEPENDENT VARIABLES: 1973

| | STOMACH CANCER | PPSQMI | PERURB | PERFEM | EIGHTEEN | SIXTYFIV | MEDAGE | FORSTOC | INC1 | INC2 | INC3 | INC4 | INC5 | INC6 | PERMANF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STOMACH CANCER | 1.00 | | | | | | | | | | | | | | |
| PPSQMI | *.36 | | | | | | | | | | | | | | |
| PERURB | .11 | *.50 | | | | | | | | | | | | | |
| PERFEM | .25 | .30 | .14 | | | | | | | | | | | | |
| EIGHTEEN | .26 | *.45 | .25 | *.46 | | | | | | | | | | | |
| SIXTYFIV | .36 | .08 | -.12 | *.66 | .57 | | | | | | | | | | |
| MEDAGE | *.33 | *.39 | .21 | *.56 | *.85 | *.75 | | | | | | | | | |
| FORSTOC | .30 | -.13 | -.17 | .01 | -.14 | .12 | -.06 | | | | | | | | |
| INC1 | -.13 | *-.38 | *-.53 | .23 | -.19 | .20 | -.13 | .00 | | | | | | | |
| INC2 | -.05 | *-.48 | *-.57 | .21 | -.15 | *.37 | -.01 | .07 | *.90 | | | | | | |
| INC3 | .01 | *-.52 | *-.68 | .09 | -.17 | .31 | -.08 | .23 | *.74 | *.89 | | | | | |
| INC4 | .06 | *.45 | *.58 | .00 | .24 | -.12 | .17 | .07 | *.92 | *-.92 | *.84 | | | | |
| INC5 | .03 | *.44 | *.62 | *-.37 | .08 | *-.47 | -.02 | -.14 | *-.79 | *-.89 | *.91 | *.74 | | | |
| INC6 | .06 | *.45 | *.59 | *-.38 | .09 | *-.44 | .00 | -.09 | *-.68 | *-.76 | *-.80 | *.57 | *.94 | | |
| PERMANF | .00 | *.36 | .16 | *.38 | *.36 | .00 | .28 | -.07 | -.15 | -.28 | -.32 | *.36 | .13 | | |

*.01 set as the research significance level.

cancer and is highly correlated to PERURB. An interesting note on the variable PERURB is the weakening correlation of this variable since 1940. This may have been caused by the interpretation of what size of a city is considered to be urban. The ethnic variable FORSTOC was negatively correlated to stomach cancer in 1960 and in 1970 and 1973 it is positively correlated to stomach cancer. The significance of FORSTOC can be attributed to improved diagnosis of the cause of death among the foreign born. During this time span some means of understanding stomach cancer has evolved among the foreign born population and also medical care has improved. The other demographic variables PERFEM, EIGHTEEN, SIXTYFIV, and MEDAGE shows positive correlation to stomach cancer.

The relationship between stomach cancer and socioeconomic variables are not fully understood and further research is definitely needed. The six levels of income are tested and showed weak correlations to stomach cancer. The independent variables which were used in this analysis may be positively and negatively correlated to stomach cancer but they do not have any probable causation to stomach cancer.

## Summary

Throughout this chapter selected independent variables were used to find statistical relationships to stomach cancer. There were several weak correlations that should have been stronger, but the weaker correlations can be as valuable as the presence of the stronger correlations. It will eliminate these variables as factors contributing to stomach cancer in the United States. The outcome of this chapter has reinforced

the fact that more investigation is needed to understand what demographic, occupational, and socioeconomic variables are linked to stomach cancer and if so, why are they linked to stomach cancer?

FOOTNOTES

[1]Perry Stocks, "Statistical Investigations Concerning the Causation of Various Forms of Human Cancer," Cancer, Vol. 3 (1958), p. 118.

[2]Ibid., p. 116.

[3]Yola Vehasselt, "Notes of Geography and Medicine," Social Science and Medicine, Vol. 11 (1977), p. 64.

[4]David M. Smith, Patterns in Human Geography: An Introduction to Numerical Methods, Crane Russak and Company, Inc. (New York, 1975), p. 82.

# CHAPTER V

# SUMMARY, IMPLICATIONS, AND FURTHER RESEARCH

## Summary

This thesis was concerned with the geography of stomach cancer in the United States. The attempt was to point out the existence of geographical variations of stomach cancer. These geographical variations exist in time and space from state to state, region to region, and country to country. There can be no doubt that stomach cancer is spatially distributed around the world and certainly warrants further geographic investigation.

The geography of stomach cancer was spatially defined in Chapter III. The portrayal of the spatial patterns were through maps which is the best means of showing the areal trends in mortality. At the national level the sensitivity limits of mortality maps must be recognized and there can be no simple explanation of the apparent mortality patterns. These mortality maps are designed to focus on states wherein detailed studies may be of benefit in discovering cause and effect relationships with stomach cancer.

The historical-geographical trends of stomach cancer were discussed in Chapter III. The outcome suggested that since 1900 the actual deaths from stomach cancer has declined. The main cause of this decline was brought about by the population's own deliberate actions. Suggested

factors were the improvement of nutritional and dietary habits and better medical diagnosis of the disease. Age-adjusted death rates put stomach cancer in a truer perspective for each state. The spatial pattern will vary according to the composition of the population for each state for age, sex, and race. The age-adjusted death rates showed the spatial pattern for the white population (male-female) and for the non-white population (male-female).

The first part of Chapter III presented the spatial pattern of stomach cancer beginning in 1900 with the Death Registration States to 1973. It was hypothesized that there are latitudinal differences in stomach cancer patterns in the United States. This hypothesis was accepted and it was concluded that stomach cancer is concentrated throughout the Northeastern, North central and Pacific states. The second half of Chapter III discussed the international comparison of stomach cancer and the hypothesis was accepted. At the international level, countries will vary in mortality and part of the explanation can be attributed to the reporting of mortality statistics from individual countries. Migrants from foreign countries will further help explain the spatial pattern of stomach cancer in the United States. Certain migrants will be susceptible to higher death rates and this will aid in finding aetiological clues. The countries that report high mortality rates are generally located in the higher latitudes.

To determine the relative importance of the dependent variable stomach cancer to the independent variables, correlation coefficients were used in Chapter IV. The analysis looked at the years from 1940 to 1973 and indicated that further investigation is needed to understand the causation from demographic, occupational, and socioeconomic

variables. The results of the analysis, overall showed demographic variables to be the most important variables in explaining stomach cancer at the national level. The third hypothesis was partially accepted concerning the statistical reliability of the demographic variables but the occupational variables were not accepted and the socioeconomic variables did not have meaningful correlations to prove any significant causation.

## Implications

The greatest difficulty encountered was working with the mortality statistics for each state. Since deaths are recorded as absolute figures instead of death rates there was the need to convert the absolute figures into death rates per 100,000 population. There was nothing else that could have been done since the data were at this level. The mortality data presented great difficulties even though the data are highly dynamic in time and space. When mortality is mapped different patterns will vary according to the statistics used. This was demonstrated in Chapter III when age-adjusted death rates were used and deaths per 100,000 were also used. Also the reporting and accuracy of mortality data is questionable and varies from state to state.

When deciding on what geographic unit to use, the state or the county, some geographic sensitivity will be lost. At the state level, which was used in this thesis, the statistical event is reduced but at the cost of geographic sensitivity. Also the interpretation of statistics may be difficult because variables are numerous and the diagnostic uniformity is low. The county offers more geographic sensitivity in variation, but are prone to large statistical errors where rates are

based upon small populations. The county will offer a better insight on the disease than the state. The death rate of a state may be high but it does not necessarily reflect the entire state since one or more counties may be responsible for the high death rate. Certain counties within the state will have the potential of producing some particular type of cancer where heavy industrial activity is located. Ohio has a high death rate of stomach cancer and the highest reported rates are located in Painesville, Ashtabula, and Avon Lake, Ohio where heavy manufacturing plants are located.[1] Also areas of Montana have excessively high death rates from stomach cancer in Butte and Anaconda, Montana where copper production is located.[2] These are only two examples depicting the variations between the state and county.

## Further Research

The role of the medical geographer will play an important part in understanding the geography of stomach cancer. The work of the medical geographer will contribute to an understanding of the etiology of cancer. The medical geographer deals primarily with the problem of who has cancer and where. This will provide strong association with environmental factors and to indicate correlations and to prove etiologic links with specific risk factors, with the aim of prevention. The wideness of the medical geographer's research will necessitate an interdisciplinary approach. Also geographical studies will continue to be important because most population statistics are gathered by geographical lines.

One of the most interesting features that will grow out of the study of stomach cancer will be the study of migrant populations. The comparison of stomach cancer incidence between migrants and indigenous groups

may reveal important geographical facts especially where stomach cancer is high. Also more research will be needed on regional foodways throughout the United States and the world. Diet has been linked to stomach cancer and with this type of knowledge available this will provide important etiologic clues on stomach cancer.

Research on identification of the factors involved in the declining deaths of stomach cancer in many counties has implications beyond the narrow confines of cancer of this particular body site. Many cancer studies and researchers believe that if such factors can be actually pinpointed, some of the basic questions about cancer in general will also be answered and will, perhaps, lead to the development of preventive measures. The role of geography will not solve stomach cancer or any other cancer but it will aid in helping and maintaining the well being of man and his environment.

FOOTNOTES

[1]Thomas H. Corbett, Cancer and Chemicals (Chicago, 1977), pp. 200-201.

[2]Ibid., p. 99.

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